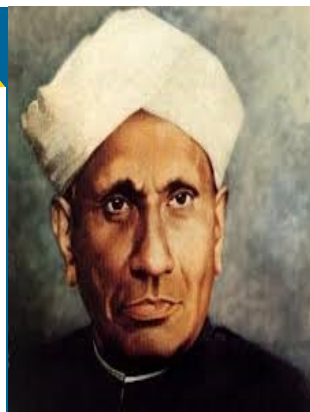


On the Eve of National Science Day : 2023

Nobel Laureate

Sir CV Raman

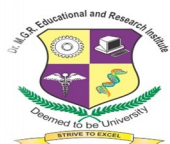


"You saw the Raman Effect on alcohol;
do not try to see the alcohol effect on Raman"



**TRIBUTE TO
NOBEL LAUREATE**

Department of Physics



Dr. M.G.R.
EDUCATIONAL AND RESEARCH INSTITUTE
DEEMED TO BE UNIVERSITY

University with Graded Autonomy Status

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Periyar E.V.R. High Road, Maduravoyal, Chennai-95. Tamilnadu, India.



Nobel Laureate

Sir C V Raman

Compiled by:

Dr NS Shubhashree

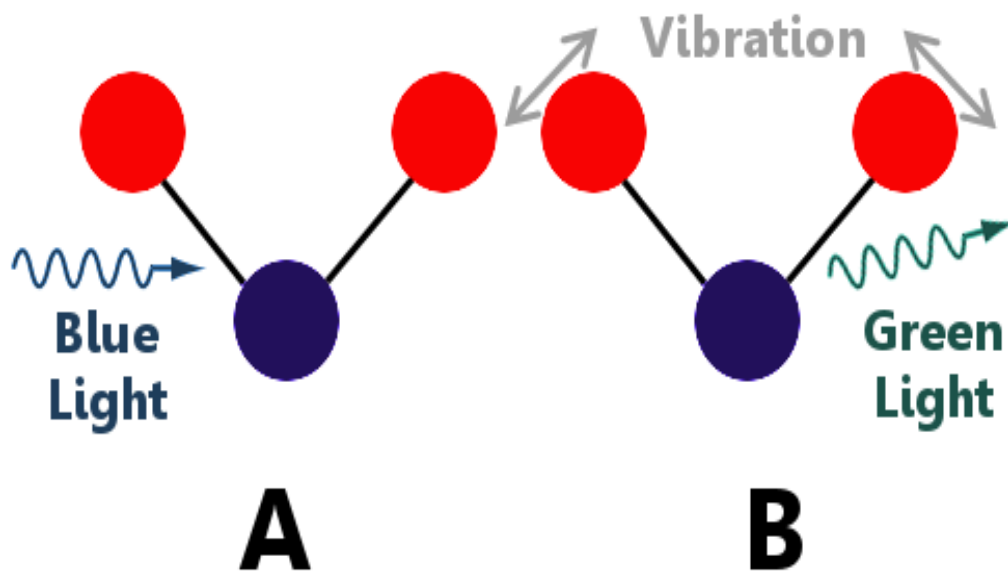
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Nobel Laureate

Sir CV Raman

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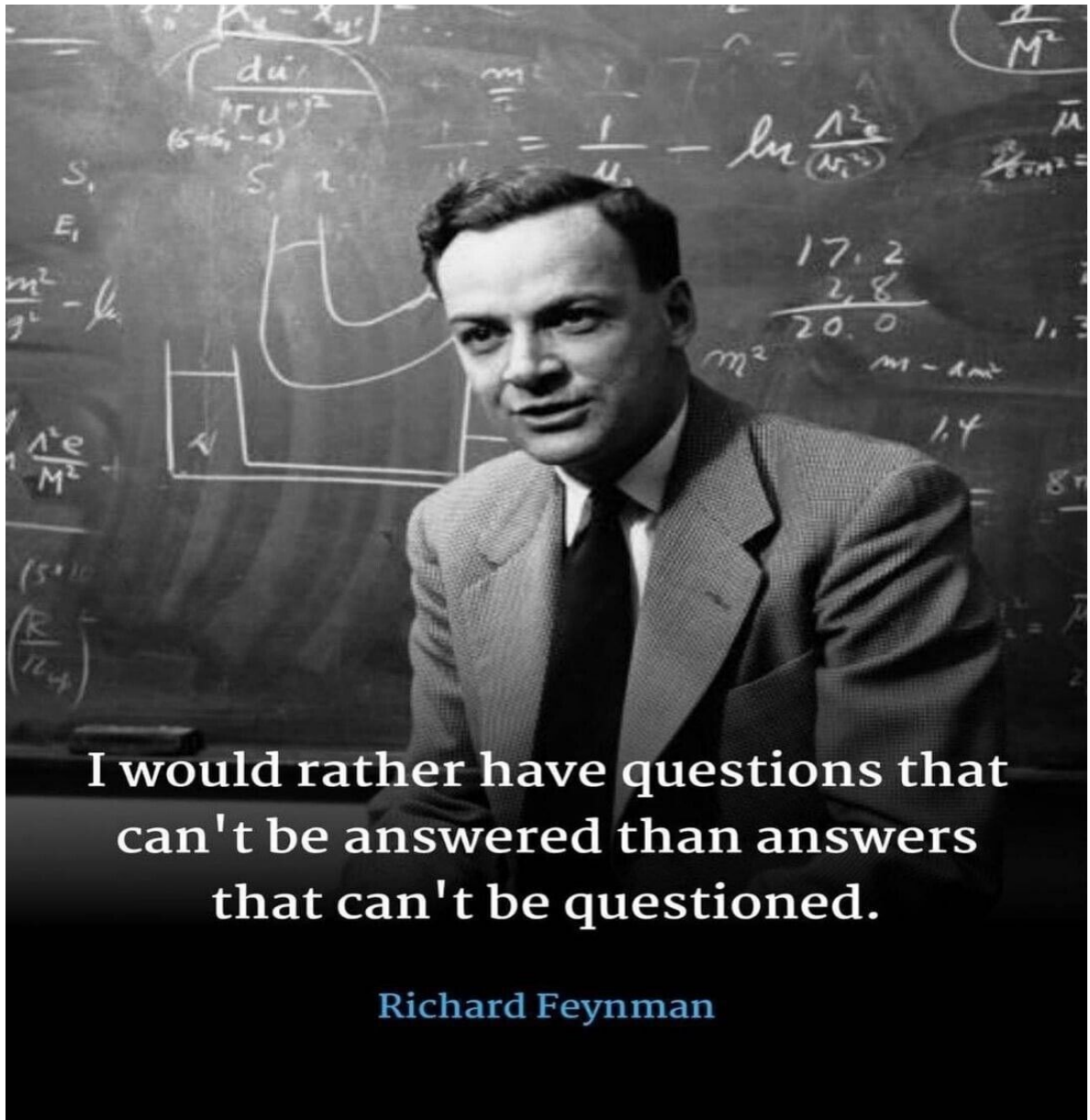


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Richard Feynman



I would rather have questions that
can't be answered than answers
that can't be questioned.

Richard Feynman

11 05 1918 : 15 02 1988

Foreword

"I propose this evening to speak to you on a new kind of radiation or light emission from atoms and molecules."

With these prophetic words, Professor C. V. Raman of University of Calcutta began his lecture to the South Indian Science Association in Bangalore on March 16, 1928.

Professor C.V. Raman was the most outstanding scientist that India gave to the world. He not only became famous for his work but put India on the scientific map. He was a very colourful personality and a brilliant spokesman for science in India. Despite the great disadvantages, namely the lack of a tradition for research in the country, the very little encouragement he received for pursuing a scientific career and the meagre equipment available, Raman rose to the pinnacle of science and eminence.

In 1921, while on a voyage to England CV Raman was amazed by the spectacular blue of the Mediterranean Sea. Seven years of research led to the Raman Effect, an explanation of the molecular diffraction of light that won him the Nobel Prize in Physics in 1930-the first non-white and first Aslan to be thus honoured.

After discovering the Raman Effect in 1928, he was knighted by the British government in India and received the Nobel Prize in physics in 1930. Three years later, Raman left Calcutta for Bangalore, where he served as head of the Indian Institute of Science. There he continued his work on the Raman Effect and became interested in the structure of crystals, especially diamond. In 1934 he

founded the Indian Academy of Science and began the publication of its Proceedings.

Biographies of great personalities in science are, therefore, all the more precious documents. Raman was famous not only for his sharp intellect, but also for his personal charm, abundant vitality and sense of humour. This brief biography - "*Nobel Laureate CV RAMAN*" - brought out by the department of Physics of our University, details Raman's growth as an individual, taking us through his childhood years, his relationships and his travels. Drawing on interviews, anecdotes, family history and other secondary sources, this book gives new insights into one of the greatest minds India has produced in the 20th century. The unique and special feature of this publication is that it contains a special chapter 'Annotated Webliography' wherein thirteen web resources containing voluminous information and details about Sir CV Raman have been meticulously annotated. I do hope that the readers would find this feature [Chapter - 28] is highly informative and useful. I appreciate the department of physics for bringing this book during the '**National Science Day**' [28 Feb 2023].

India's Sir CV Raman is remembered across the world for his immense contribution to the field of science and research.

Dr P Kalidoss
Sr Additional Registrar
Dr MGR Education and Research Institute
Maduravoyal, Chennai – 600 095

Preface

The lives of men and women who achieve great distinction in science, literature or art hold a great fascination for the general public. A creative accomplishment standing well above even superior excellence is awe-inspiring.

Raman was fiercely independent in thought and action and fearless in expressing his views. He was respected and honoured by princes, maharajahas, politicians and the general public. The mention of the name Sir C.V. Raman evoked respect and admiration everywhere in India.

A topper throughout his academic days, he was deeply interested in research; in fact, he began his research work on optics and acoustics even while he was a student. Even though he started his career as a Deputy Accountant General, still he could not keep away from research, often staying up whole nights to discover new things in the field of physics. He was intrigued by the blue colour of glaciers and the Mediterranean Sea and wanted to unravel the mystery that why water, a colorless liquid, appeared blue to the eyes. Thus began a series of experiments on the scattering of light which ultimately led to what came to be known as the 'Raman Effect' for which he won the Nobel Prize in Physics in 1930.

After the Nobel Prize ceremony, a party was organized to all the winners and other scientists and dignitaries. During the party Raman

was offered some drinks. Being a complete teetotaler, Raman's reaction was:

*"You saw the Raman Effect on alcohol;
do not try to see the alcohol effect on Raman"*

The effect of these words on the gathering is too obvious.

Sir C.V. Raman, the discoverer of the Raman effect, made numerous innovative and original contributions to modern physics, optics and acoustics during the first half of 20th century. By his scientific accomplishments and by his unique scientific leadership in modern India, he made a profound impact.

His disciples came from all parts of India. He kindled their scientific interest and curiosity, and communicated to them the scientific spirit and the joy of scientific research. Many of his students and associates became in their lifetime's leaders of science and, in turn, created their own schools of research.

He wrote his scientific papers with meticulous care and often used Latin expressions to emphasize a point. His flow and style of English were extraordinarily lucid; reading his scientific memoirs is like reading a piece of literary exposition.

He founded several scientific journals and nurtured them with care, for he believed that the quality of work and the quality of a journal go together. He published most of his scientific papers in these journals and encouraged his students and coworkers to do the same.

After his formal retirement from the Indian Institute of Science he founded the Raman Research Institute to pursue his scientific interests, for retirement from scientific work was inconceivable for Raman. In 1948 he became director of the newly constructed Raman

Research Institute, where he remained continually active, delivering his last lecture just two weeks before his death [21 Nov 1970]. His research interests changed in later years when he primarily investigated the perception of color.

Always a nationalist, Raman strove to win a place for India in the international arena by mentoring scores of students, many of whom became renowned scientists; he also organized conferences for the promotion of scientific inquiry and founded significant journals.

The department of physics of Dr MGR Educational and Research Institute decided to celebrate the 'National Science Day' [28 February 2023] by bringing a small and compact book titled: "*Nobel Laureate Sir CV Raman*", containing 29 chapters. A serious and sincere efforts are by the authors to touch all aspects of Raman's life - personal, scientific, national and international - and make the book, as far as possible, more interesting and useful to this younger generation of the 21st century by providing interesting and more appropriate details and information.

For example, the chapters (i) A Pictorial Biography: Sir CV Raman, (ii) Scientific Papers of CV Raman, (iii) Sir CV Raman - A Memoir, (iv) Max Born @ IISc, Bangalore, (v) The Quantum Indians [A Film], (vi) PHYSIS - Nobel Prize (containing the list of Nobel Prize winners in Physics from 1901 to 2023) would be found more useful by general public as well as by young science students.

Raman was a very inspiring and colourful personality, and his contributions to science in India will last forever.

AUTHORS

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<https://www.britannica.com/biography/C-V-Raman>

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Nobel Prize



Key facts:

Full name: Sir Chandrasekhara Venkata Raman

Born: 7 November 1888, Tiruchirappalli, southern India

Died: 21 November 1970, Bangalore, aged 82

Sir Chandrasekhara Venkata Raman was an Indian physicist famous for contributions to the physics of light for which he won the Nobel prize in Physics in 1930 for his discovery of the Raman effect.

Please visit:

<https://www.nobelprize.org/prizes/physics/1930/raman/biographical/>



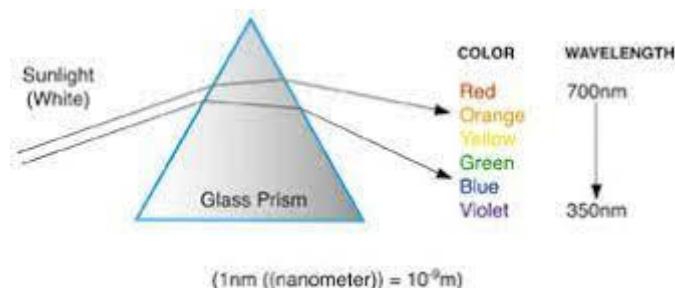
**Raman at the 1930 Nobel Prize Award Ceremony with other winners,
from left C. V. Raman (physics), Hans Fischer (chemistry),
Karl Landsteiner (medicine) and Sinclair Lewis (literature)**

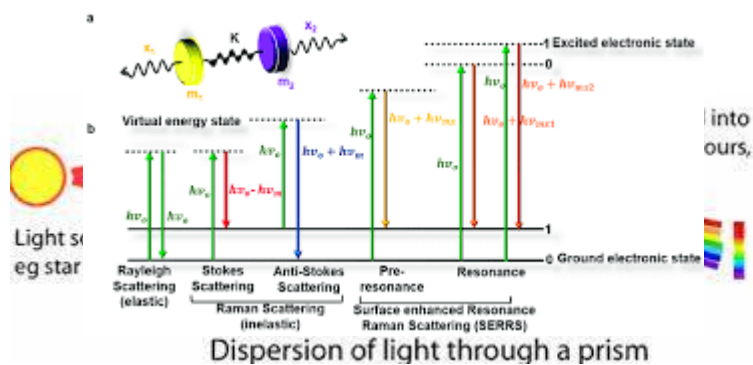
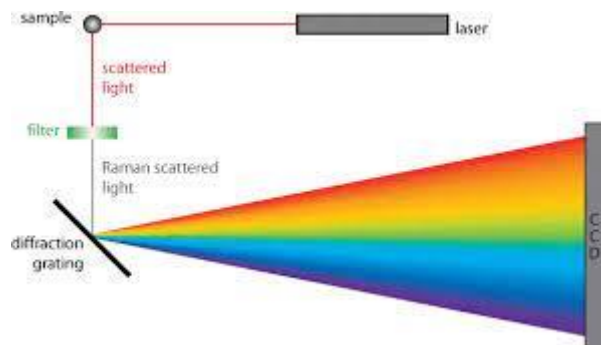
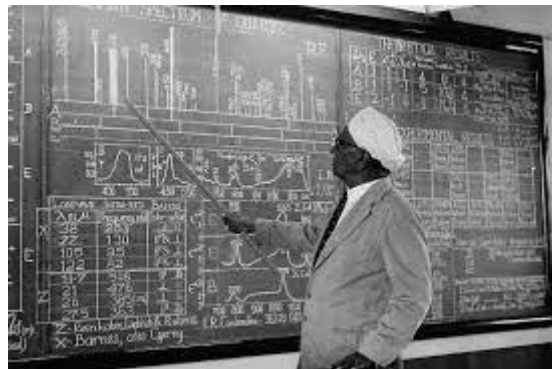
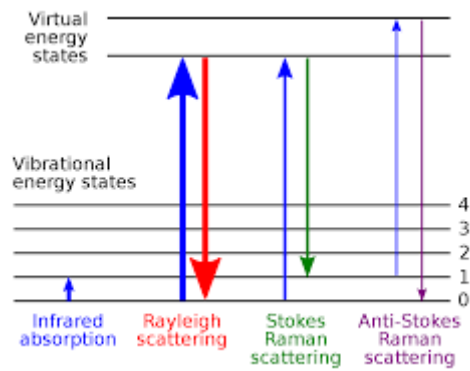
Talented and ambitious from the first, for Indian physicist C. V. Raman, winning the Nobel prize for physics was not so much a distant aspiration as a career plan. He was the first person of colour and the first Asian to receive the award, following the discovery of a light scattering effect that has since become a key characterisation tool in materials science.

Never one to undersell his achievements, Raman was sure the discovery merited a Nobel prize, and was consequently a little miffed when the prize was awarded elsewhere in both 1928 and 1929. However, the following year he was so confident he would win, he booked tickets to attend the ceremony in July, four months before the award was announced. As it turns out his money wasn't wasted. Raman was awarded the 1930 Nobel prize in physics "for his work on the scattering of light and for the discovery of the effect named after him".

The award wasn't without controversy as it was awarded to him alone, despite the contributions by his research associate Krishnan, as well as independent discoveries of the same effect by Russian physicists Grigori Landsberg and Leonid Mandelstam at Moscow University.

A further controversy unfolded over a long-upheld dispute with the German physicist Max Born over the vibration spectrum of diamond, an argument where posterity has found him in the wrong. Nonetheless, he made many significant contributions to physics, and the institutions he founded and helped establish have been integral in putting India on the map in physics. National Science Day is celebrated on 28 February each year in India to mark the discovery of Raman scattering.





Information available in the Nobel Prize Website:

Facts

Sir Chandrasekhara Venkata Raman
Photo from the Nobel Foundation archive.
Sir Chandrasekhara Venkata Raman
The Nobel Prize in Physics 1930

Born: 7 November 1888, Tiruchirappalli, India

Died: 21 November 1970, Bangalore, India

**Affiliation at the time of the award: Calcutta University,
Calcutta, India**

**Prize motivation: "for his work on the scattering of light and for
the discovery of the effect named after him"**

Prize share: 1/1

Work

When light meets particles that are smaller than the light's wavelength, the light spreads in different directions. This occurs, for example, when light packets—photons—encounter molecules in a gas. In 1928 Venkata Raman discovered that a small portion of the scattered light acquires other wavelengths than that of the original light. This is because some of the incoming photons' energy can be transferred to a molecule, giving it a higher level of energy. Among other things, the phenomenon is used to analyze different types of material.

Biographical



Chandrasekhara Venkata Raman was

born at Tiruchirappalli in Southern India on November 7th, 1888. His father was a lecturer in mathematics and physics so that from the first he was immersed in an academic atmosphere. He entered Presidency College, Madras, in 1902, and in 1904 passed his B.A. examination, winning the first place and the gold medal in physics; in 1907 he gained his M.A. degree, obtaining the highest distinctions.

His earliest researches in optics and acoustics – the two fields of investigation to which he has dedicated his entire career – were carried out while he was a student.

Since at that time a scientific career did not appear to present the best possibilities, Raman joined the Indian Finance Department in 1907; though the duties of his office took most of his time, Raman found opportunities for carrying on experimental research in the laboratory of the Indian Association for the Cultivation of Science at Calcutta (of which he became Honorary Secretary in 1919).

In 1917 he was offered the newly endowed Palit Chair of Physics at Calcutta University, and decided to accept it. After 15 years at Calcutta he became Professor at the Indian Institute of Science at Bangalore (1933-1948), and since 1948 he is Director of the Raman Institute of Research at Bangalore, established and endowed by himself. He also founded the *Indian Journal of Physics* in 1926, of which he is the Editor. Raman sponsored the establishment of the Indian Academy of Sciences and has served as President since its inception. He also initiated the *Proceedings* of that academy, in which much of his work has been published, and is President of the Current Science Association, Bangalore, which publishes *Current Science (India)*.

Some of Raman's early memoirs appeared as Bulletins of the *Indian Association for the Cultivation of Science* (Bull. 6 and 11, dealing with the "Maintenance of Vibrations"; Bull. 15, 1918, dealing with the theory of the musical instruments of the violin family). He contributed an article on the theory of musical instruments to the 8th Volume of the *Handbuch der Physik*, 1928. In 1922 he published his work on the "Molecular Diffraction of Light", the first of a series of investigations with his collaborators which ultimately led to his discovery, on the 28th of February, 1928, of the radiation effect which bears his name ("A new radiation", *Indian J. Phys.*, 2 (1928) 387), and which gained him the 1930 Nobel Prize in Physics.

Other investigations carried out by Raman were: his experimental and theoretical studies on the diffraction of light by acoustic waves of ultrasonic and hypersonic frequencies (published 1934-1942), and those on the effects produced by X-rays on infrared vibrations in crystals exposed to ordinary light. In 1948 Raman, through studying the spectroscopic behaviour of crystals, approached in a new manner fundamental problems of crystal dynamics. His laboratory has been dealing with the structure and properties of diamond, the structure and optical behaviour of numerous iridescent substances (labradorite, pearly felspar, agate, opal, and pearls).

Among his other interests have been the optics of colloids, electrical and magnetic anisotropy, and the physiology of human vision.

Raman has been honoured with a large number of honorary doctorates and memberships of scientific societies. He was elected a Fellow of the Royal Society early in his career (1924), and was knighted in 1929.

This autobiography/biography was written at the time of the award and first published in the book series [Les Prix Nobel](#). It was later edited and republished in [Nobel Lectures](#). To cite this document, always state the source as shown above.

Sir Chandrasekhara Venkata Raman – died on November 21, 1970.

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Nobel Lecture
SIR C HANDRASEKHARA V. RAMAN
The molecular scattering of light
Nobel Lecture, December 11, 1930
The colour of the sea

In the history of science, we often find that the study of some natural phenomenon has been the starting-point in the development of a new branch of knowledge. We have an instance of this in the colour of skylight, which has inspired numerous optical investigations, and the explanation of which, proposed by the late Lord Rayleigh, and subsequently verified by observation, forms the beginning of our knowledge of the subject of this lecture. Even more striking, though not so familiar to all, is the colour exhibited by oceanic waters. A voyage to Europe in the summer of 1921 gave me the first opportunity of observing the wonderful blue opalescence of the Mediterranean Sea. It seemed not unlikely that the phenomenon owed its origin to the scattering of sunlight by the molecules of the water. To test this explanation, it appeared desirable to ascertain the laws governing the diffusion of light in liquids, and experiments with this object were started immediately on my return to Calcutta in September, 1921. It soon became evident, however, that the subject possessed a significance extending far beyond the special purpose for which the work was undertaken, and that it offered unlimited scope for research. It seemed indeed that the study of light-scattering might carry one into the deepest problems of physics and chemistry, and it was this belief which led to the subject becoming the main theme of our activities at Calcutta from that time onwards.

The theory of fluctuations

From the work of the first few months, it became clear that the molecular scattering of light was a very general phenomenon which could be studied not only in gases and vapours but also in liquids and in crystalline and amorphous solids, and that it was primarily an effect arising from molecular disarray in the medium and consequent local fluctuations in its optical density. Except in amorphous solids, such molecular disarray could presumably be ascribed to thermal agitation, and the experimental results appeared to support this view. The fact that molecules are optically anisotropic and can orientate freely in liquids was found to give rise to an additional type of scattering. This could be distinguished from the scattering due to fluctuations in density by reason of its being practically unpolarized, whereas the latter was completely polarized in the transverse direction. The whole subject was critically reviewed and the results till then obtained were set out in an essay published by the Calcutta University Press in February 1922.

The various problems requiring solution indicated in this essay were investigated with the aid of a succession of able collaborators. It is possible to mention briefly only a few of the numerous investigations which were carried out at Calcutta during the six years 1922 to 1927. The scattering of light in fluids was studied by Ramanathan over a wide range of pressures and temperatures with results which appeared to support

the "fluctuation" theory of its origin. His work also disclosed the remarkable changes in the state of polarization which accompany the variations of intensity with temperature in vapours and in liquids. Liquid mixtures were investigated by Kameswara Rao, and furnished optical proof of the existence in such systems, of simultaneous fluctuations of density, composition, and molecular orientation. Srivastava studied the scattering of light in crystals in relation to the thermal fluctuations of density and their increase with temperature. Ramdas investigated the scattering of light by liquid surfaces due to thermal agitation, and established a relation between surface-tension and surface-opalescence. He also traced the transition from surface-opalescence to volume-opalescence which occurs at the critical temperature. Sogani investigated X-ray diffraction in liquids, in order to connect it with their optical behaviour, and test the application of fluctuation theory to X-ray scattering.

The anisotropy of molecules

As stated above, the state of polarization of the light scattered in fluids is connected with the optical anisotropy of the molecules. Much of the work done at Calcutta during the years 1922 to 1927 was intended to obtain data concerning this property and to establish its relations with various optical phenomena. Krishnan examined a great many liquids, and by his work showed very clearly the dependence of the optical anisotropy of the molecule on its chemical constitution. Ramakrishna Rao studied the depolarization of scattered light in a very large number of gases and vapours, and obtained information of high importance for the progress of the subject. Venkateswaran studied the scattering of light in aqueous solutions to find the influence on it of electrolytic dissociation. Ramachandra Rao investigated liquids having highly elongated molecules and also highly polar substances over a wide range of temperatures, and discovered the influence of molecular shape and molecular association on the depolarization of scattered light in liquids.

The interpretation of the observations with liquids involved the development of a molecular theory of light-scattering in dense media which was undertaken by Ramanathan, myself, and Krishnan. A revised opalescence formula was derived which differed from that of Einstein and yielded results in better agreement with observation. Krishnan and myself also published a series of investigations showing how the optical anisotropy of the molecules deduced from light-scattering could be utilized to interpret the optical and dielectric behaviour of fluids, and also the electric, magnetic, and mechanical birefringence exhibited by them. The conclusions derived from these studies enabled a connection to be established between the molecular anisotropy observed in fluids and the optical, electric, and magnetic anisotropy exhibited by solids in the crystalline state.

The new phenomenon

The investigations referred to above were in the main guided by the classical electromagnetic theory of light, the application of which to the problems of light-scattering is chiefly associated with the names of Rayleigh and of Einstein. Nevertheless, the possibility that the corpuscular nature of light might come into

evidence in scattering was not overlooked and was in fact elaborately discussed in the essay of February 1922 which was published at least a year before the well-known discoveries of Compton on X-ray scattering. While our experiments in the main appeared to support the electromagnetic theory of light, evidence came to hand at a very early stage of the investigations of the existence of a phenomenon which seemed to stand outside the classical scheme of thought. The scattering of light in transparent fluids is extremely feeble, much weaker in fact than the Tyndall effect usually observed in turbid media. It was experimentally discovered that associated with the Rayleigh-Einstein type of molecular scattering, was another and still feebler type of secondary radiation, the intensity of which was of the order of magnitude of a few hundredths of the classical scattering, and differed from it in not having the same wavelength as the primary or incident radiation. The first observation of this phenomenon was made at Calcutta in April 1923 by Ramanathan who was led to it in attempting to explain why in certain liquids (water, ether, methyl and ethyl alcohols), the depolarization of scattered light varied with the wavelength of the incident radiation. Ramanathan found that after exhaustive chemical purification and repeated slow distillation of the liquid in vacuum, the new radiation persisted undiminished in intensity, showing that it was a characteristic property of the substance studied and not due to any fluorescent impurity. Krishnan observed a similar effect in many other liquids in 1924, and a somewhat more conspicuous phenomenon was observed by me in ice and in optical glasses.

The optical analogue of the Compton effect

The origin of this puzzling phenomenon naturally interested us, and in the summer of 1925, Venkateswaran attempted to investigate it by photographing the spectrum of the scattered light from liquids, using sunlight filtered through colour screens, but was unable to report any decisive results. Ramakrishna Rao in his studies on the depolarization of scattering during 1926 and 1927 looked carefully for a similar phenomenon in gases and vapours, but without success. This problem was taken up again by Krishnan towards the end of 1927. While his work was in progress, the first indication of the true nature of the phenomenon came to hand from a different quarter. One of the problems interesting us at this time was the behaviour in light-scattering of highly viscous organic liquids which were capable of passing over into the glassy state. Venkateswaran undertook to study this question, and reported the highly interesting result that the colour of sunlight scattered in a highly purified sample of glycerine was a brilliant green instead of the usual blue. The phenomenon appeared to be similar to that discovered by Ramanathan in water and the alcohols, but of much greater intensity, and, therefore, more easily studied. No time was lost in following up the matter. Tests were made with a series of filters transmitting narrow regions of the solar spectrum and placed in the path of the incident beam, which showed that in every case the colour of the scattered light was different from that of the incident light, and was displaced from it towards the red. The radiations were also strongly polarized. These facts indicated a clear analogy between the empirical characters of the phenomenon and the Compton effect. The work of Compton had made familiar the idea that the wavelength of radiation could be degraded in the process of scattering, and the observations with glycerine suggested to me that the phenomenon

which had puzzled us ever since 1923 was in fact the optical analogue of the Compton effect. This idea naturally stimulated further investigation with other substances.

The chief difficulty which had hitherto oppressed us in the study of the new phenomenon was its extreme feebleness in general. This was overcome by using a 7-inch refracting telescope in combination with a short-focus lens to condense sunlight into a pencil of very great intensity. With these arrangements and using complementary light-filters in the path of the incident and scattered beams, as was done by Ramanathan in 1923, to isolate the modified radiations, it was found that they could be readily observed in a great many liquids, and that in many cases they were strongly polarized. Krishnan, who very materially assisted me in these investigations, found at the same time that the phenomenon could be observed in several organic vapours, and even succeeded in visually determining the state of polarization of the modified radiations from them. Compressed gases such as CO, and N₂O, crystalline ice, and optical glasses also were found to exhibit the modified radiations. These observations left little doubt that the phenomenon was really a species of light-scattering analogous to the Compton effect.

The spectroscopic characters of the new effect

Thanks to the vastly more powerful illumination made available by the 7-inch refractor, the spectroscopic examination of the effect, which had been abandoned in 1925 as indecisive, now came within the reach of direct visual study. With a Zeiss cobalt-glass filter placed in the path of the incident beam and one or other of a series of organic liquids as the scattering substance, a band in the blue-green region was observed by me in the spectrum of the scattered light, separated by a dark interval from the indigo-violet region transmitted by the filter. Both of these regions in the spectrum became sharper when the region of transmission was narrowed by the insertion of an additional filter in the incident beam. This suggested the employment, instead of sunlight, of the highly monochromatic radiations given by a mercury arc in combination with a condenser of large aperture and a cobalt-glass filter. With these arrangements the spectrum of the scattered light from a variety of liquids and solids was visually examined, and the startling observation was made that the spectrum generally included a number of sharp lines or bands on a diffuse background which were not present in the light of the mercury arc.

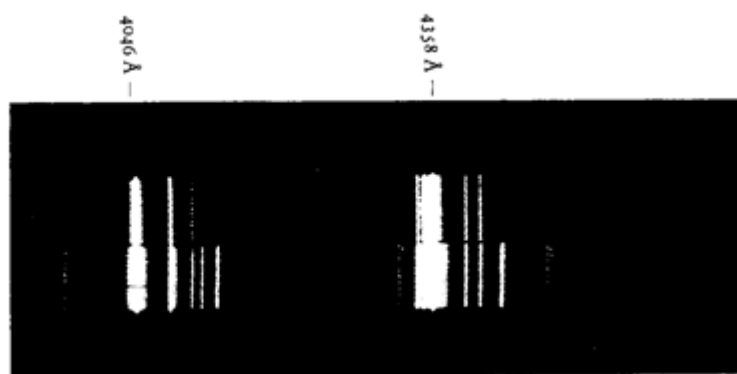


Fig. I. Spectrum of carbon tetrachloride.

The quartz mercury lamp was so powerful and convenient a source of monochromatic illumination that, at least in the case of liquids and solids, photographing the spectrum of scattered light was found to present no extraordinary difficulties. The earliest pictures of the phenomenon were in fact taken with a portable quartz spectrograph of the smallest size made by the firm of Hilger. With a somewhat larger instrument of the same type, Krishnan obtained very satisfactory spectrograms with liquids and with crystals on which measurements of the desired precision could be made, and on which the presence of lines displaced towards the violet was first definitely established. The experimental difficulties were naturally greater in the case of gases or vapours, though they could be lessened by working with the substance under pressure. With an improvised instrument of large aperture ($F/1.8$), Ramdas obtained the first spectrograms with a gaseous substance (ether vapour) at atmospheric pressure. In interpreting the observed phenomena, the analogy with the Compton effect was adopted as the guiding principle. The work of Compton had gained general acceptance for the idea that the scattering of radiation is a unitary process in which the conservation principles hold good. Accepting this idea it follows at once that, if the scattering particle gains any energy during the encounter with the quantum, the latter is deprived of energy to the same extent, and accordingly appears after scattering as a radiation of diminished frequency. From thermodynamic principles, it follows that the reverse process should also be possible. Adopting these ideas, the actual observations could be interpreted, and the agreement of the observed displacements with the infrared frequencies of the molecules made it clear that the new method opened up an illimitable field of experimental research in the study of the structure of matter.

Interpretation of the effect

It appears desirable to emphasize that though the conservation principle of Compton is useful in interpreting the effects disclosed by experiment, it is by itself insufficient to explain the observed phenomena. As is well known from studies on molecular spectra, a gaseous molecule has four different species of energy of increasing orders of magnitude, namely those corresponding to translatory motion, rotation, vibration, and electronic excitation. Each of these, except the first, is quantized and may be represented by an integer in an extended sequence of quantum numbers. The aggregate energy of a molecule may, therefore, assume any one out of a very large number of possible values. If we assume that an exchange of energy occurs in the collision between the molecule and the quantum, and limit ourself to the cases in which the final energy of the molecule is less than that of the incident quantum, we arrive at the result that the spectrum of the scattered light should contain an immense number of new lines and should in fact rival in its complexity the band spectrum of the molecule observed in the emission or absorption of light. Nothing more different from what is actually observed can be imagined than the foregoing picture. The most conspicuous feature revealed by experiment is the beautiful simplicity of the spectra of even complicated polyatomic molecules obtained in light-scattering, a simplicity that is in striking contrast to the extreme complexity of their emission or absorption spectra. It is this simplicity that gives to the study of light-scattering its special

significance and value. It is clear that the effect actually observed was not and could not have been foreseen from an application of the conservation principles.

The general principle of correspondence between the quantum and classical theories enunciated by Niels Bohr enables us, on the other hand, to obtain a real insight into the actual phenomena. The classical theory of light scattering tells us that if a molecule scatters light while it is moving, rotating or vibrating, the scattered radiations may include certain frequencies, different from those of the incident waves. This classical picture, in many respects, is surprisingly like what we actually observe in the experiments. It explains why the frequency shifts observed fall into three classes, translational, rotational and vibrational, of different orders of magnitude. It explains the observed selection rules, as for instance, why the frequencies of vibration deduced from scattered light include only the fundamentals and not the overtones and combinations which are so conspicuous in emission and absorption spectra. The classical theory can even go further and give us a rough indication of the intensity and polarization of the radiations of altered frequency. Nevertheless, the classical picture has to be modified in essential respects to give even a qualitative description of the phenomena, and we have, therefore, to invoke the aid of quantum principles. The work of Kramers and Heisenberg, and the newer developments in quantum mechanics which have their root in Bohr's correspondence principle seem to offer a promising way of approach towards an understanding of the experimental results. But until we know much more than we do at present regarding the structure of molecules, and have sufficient quantitative experimental knowledge of the effect, it would be rash to suggest that they afford a complete explanation of it.

The significance of the effect

The universality of the phenomenon, the convenience of the experimental technique and the simplicity of the spectra obtained enable the effect to be used as an experimental aid to the solution of a wide range of problems in physics and chemistry. Indeed, it may be said that it is this fact which constitutes the principal significance of the effect. The frequency differences determined from the spectra, the width and character of the lines appearing in them, and the intensity and state of polarization of the scattered radiations enable us to obtain an insight into the ultimate structure of the scattering substance. As experimental research has shown, these features in the spectra are very definitely influenced by physical conditions, such as temperature and state of aggregation, by physico-chemical conditions, such as mixture, solution, molecular association and polymerization, and most essentially by chemical constitution. It follows that the new field of spectroscopy has practically unrestricted scope in the study of problems relating to the structure of matter. We may also hope that it will lead us to a fuller understanding of the nature of light, and of the interactions between matter and light.

Some concluding remarks

From a physical point of view, the quantitative study of the effect with the simplest molecules holds out the largest hope of fundamental advances. The beautiful work of McLennan with liquefied gases, and of R. W. Wood and Rasetti are pioneer

investigations in this field which command the highest admiration. The quantitative study of the effect with crystals of the simplest possible chemical constitution is naturally of great importance. The case of the diamond, which has been investigated by Ramaswamy, Robertson, and Fox, and with especial completeness by Bhagavantam, is of special interest. Very surprising results have been obtained with this substance, which may be the pathway to a fuller understanding of the nature of the crystalline state. I should also like to draw attention to the work of Krishnamurti, who has traced a remarkable dependence of the intensity of the spectral lines observed in scattering on the nature of the chemical bond, and followed the transition from the homopolar to the heteropolar type of chemical combination. Krishnamurti's observation that the paramagnetism of crystals apparently influences the observed intensity of the displaced lines is one of the most remarkable ever made in this new field of research.

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Biography

Sir CV Raman

Sir Chandrasekhara Venkata Raman, was an Indian physicist who won the Nobel Prize in Physics in 1930 for his work on light scattering and the discovery of a new form of scattering called Raman scattering or the Raman effect.

The compositions of solids, liquids, and gases can all benefit from this effect. It can also be used to diagnose diseases and track manufacturing processes.

Basic Information:

- **Sir CV Raman's birthday-** November 7, 1888
- **Sir C V Raman's death day-** November 21, 1970
- **Alma Mater-** The University of Madras (M.A.)
- **Known for** Raman effect
- **Spouse-** Lokasundari Ammal (1908-1970)
- **Children-** Chandrasekhar Raman and Venkatraman Radhakrishnan

Chandrasekhara Venkata Raman was born to a Tamil Brahmin family in Tiruchirapalli, Tamil Nadu, on November 7, 1888. Raman's forefathers were agriculturists who settled in the Tanjore district near Porasakudi Village and Mangudi. Chandrasekhara Iyer, his father, attended a school in Kumbakonam and graduated with honours in 1881. He eventually earned a Bachelor of Arts degree in Physics from Tiruchirapalli's Society of the Promotion of the Gospel College in 1891. In the same college, Chandrasekhara became a lecturer. He married Parvathi Ammal after passing the Matriculation exam and they had eight children: five sons and three daughters.



Chandrasekhara Iyer and Family. Raman extreme left

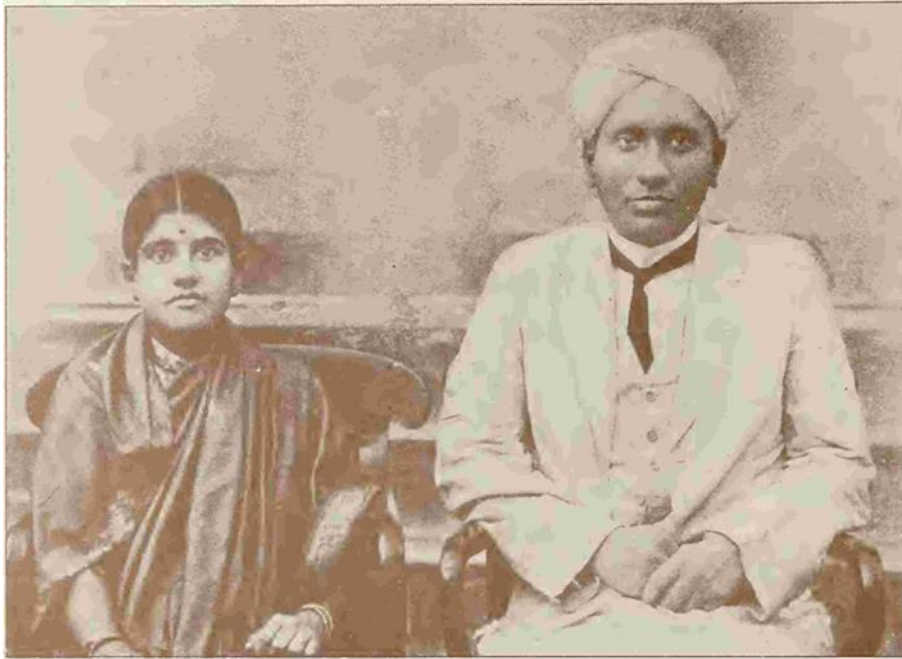
Chandrasekaran, Raman's father, moved to Visakhapatnam when he was four years old to work as a lecturer at Mrs. A.V. Narasimha Rao College. He taught Physics, arithmetic, and physical geography at the university. Chandrasekaran was regarded as physically and mentally powerful due to his involvement in athletics, physical culture, and Indian Carnatic music, among other things. Raman, unlike his father, was not physically powerful, but he was a brilliant thinker. He excelled in school and displayed early signs of exceptional ability, receiving praise from his teachers as well as numerous prizes and scholarships. While still in school, Raman developed an interest in Physics. He once designed a dynamo on his own and was fascinated with how physical principles and machines worked. C. V. Raman graduated from high school at the age of eleven, receiving first place in the Matriculation Examination (top marks). He then enrolled in the AVN College to prepare for the Intermediate Exam. He received more accolades this time, and he received top scores on the university test. In 1903, he received a scholarship to study for a BA degree at the Presidency College in Chennai (then Madras), where he was the youngest student. At the time, the Presidency College was the best in Southern India. When Raman was in college, the majority of his professors were Europeans. Raman's interest in Physics grew even stronger during this period, and he also developed a strong liking for English. Raman earned first place in the university's BA exams in 1904, and gold medals in English and Physics. Raman's teachers encouraged him to continue his education in England, but the Madras Civil Surgeon refused, arguing that the young Raman was too weak to endure

the English climate. Raman, on the other hand, completed his MA in Physics at Presidency College and did not travel abroad until he was thirty-three years old.



Room in which Raman was born.

In January 1907, Raman sat for and passed his Master's examination, earning top marks and a slew of awards and prizes. While he desired to focus on science (particularly research), there were no research opportunities in India (specifically for Indians). Owing to his deteriorating health at the time, he was unable to travel to England. As a result, Raman's thoughts turned to work for the government, which is known to be clean, stable, and even prestigious. Even in this situation, he desired to enter the prestigious Indian Civil Service (ICS), the highest level of government service, but this meant training in England and taking the exam there—an option that was also ruled out due to medical reasons. The Financial Civil Service (FCS), where Raman's brother C.S. Iyer was already a member, which was his next preference. The FCS served as a forerunner to today's Indian Audit and Accounts Service. Raman passed the FCS examination in 1907 and married Lokasundari before taking up an official job.



Raman with his wife, Lokasundari

This period of his life unfolded unusually. Typically, parents arranged Indian marriages, which includes finding a suitable horoscope match for their infant. This included looking at the positions of the stars on their birth date, as well as other horoscopic statistics. The boy and his parents then pay a visit to the girl's house to see if she likes them; during this period, the girl is normally asked to give a musical performance. The date for their marriage is fixed if all arrangements are in agreement and the girl's family provides adequate dowry. Raman's marriage went in a different direction. Mr. Ramaswamy Sivan, a freemason, theosophist, and radical thinker, was a friend of Raman's as a college student. Mr. Sivan's house was a frequent stop for Raman, and one day he heard music from an Indian classical instrument, the veena, played by Lokasundari, Sivan's sister-in-law, who was visiting from Madurai. Lokasundari was a natural at playing the veena, and Raman was instantly drawn to her. Sivan discussed this idea with Raman, who immediately accepted it since Lokasundari was of marriageable age at the time and her family was looking for a suitable groom. Raman then continued to seek permission from his parents. However, it was later discovered that Lokasundari, thought of the same caste as Raman (Brahmin), belonged to a separate subset—a match that was strictly forbidden at the time. Raman's father, who is a rather liberal man, agreed that Raman could choose his bride, even if she came from a different subset. The rest of the family, including Raman's mother, was unhappy, however. Despite these challenges, Raman followed his heart and kept

on doing things his way. In mid-1907, Raman was appointed Assistant Accountant-General in Calcutta, even though he was still a teenager.

His pay, including the marriage allowance, was Rs. 400 at the time. Raman and Lokasundari set out for Calcutta, the capital of British India at the time. Raman took advantage of Calcutta's vibrant and scientific environment, allowing him to fully articulate his scientific creativity—Calcutta was then regarded as the East's premier science city. Raman was sent to Nagpur and Rangoon in addition to Calcutta; no matter where he was posted, Raman still found a way to perform experiments at home.

Sir CV Raman's Contribution to Science

Raman productively used the time he had with Professor Jones while studying Physics at Presidency College, designing and creating experiments to address the boundless questions he had. Only the most basic laboratory instruments (enough for classwork) were available in the Physics lab at the time, but Raman made use of them all. Raman's questions were frequently those for which there were no answers in the literature. As a result, the nature of science came naturally to him, prompting him to perform experiments throughout his life. Raman experimented with asymmetric diffraction of light though he was well aware of light in a wave shape and the principle of diffraction. Professor Jones was given his observations on this experiment, which he collected and gave to him for feedback. Professor Jones, on the other hand, remained silent for many months. Raman was aware of the Philosophical Magazine at the time, possibly those subscribed to by the Connemara Public Library, which was about five kilometers from Presidency College (it is not certain how Raman came to know of this magazine). This paper was written in 1906, and Raman, who was only 18 at the time and had not yet graduated from high school, was the sole author with no acknowledgments. Raman's achievement was all the more remarkable because Presidency College was not a research institution, and Raman's paper was the first to emerge from there.

Almost immediately after Raman's first publication, Johns Hopkins University's R.W. Wood published another. Wood later sent a cable to Nature announcing the Raman Effect's discovery. Raman left the government in 1917 to take up the newly established Palit Professorship in Physics at the University of Calcutta. Simultaneously, he continued his study at the IACS, where he eventually rose to the position of Honorary Secretary. Raman referred to this period in his career

as his "golden age." At the IACS and the University of Calcutta, he was surrounded by a group of gifted students. In 1929, he presided over the 16th session of the Indian Science Congress. Raman worked on the acoustics of musical instruments in addition to his Nobel Prize-winning work on light scattering. Based on superposition velocities, he developed a theory of transverse vibration of bowed strings. In comparison to Helmholtz's method, this does a great job of describing bowed string vibration. He was also the first to explore the harmonic essence of Indian drum sounds like the tabla and mridangam. Raman was appointed director of the newly established Indian Institute of Science (IISc) in Bangalore in 1933. The IISc was established in 1909 with the aim of conducting original research and providing science and engineering education. Before Raman's appointment, all of IISc's directors, as well as the majority of its faculty, were British. He remained a Professor of Physics for another two years. The new government of Independent India named him the country's first National Professor in 1947. In 1948, he retired from the Indian Institute of Science and a year later founded the Raman Research Bangalore, Karnataka, where he served as director until he died in 1970.

CV Raman's Invention of Raman Effect

CV Raman Discovery of the Physics of Musical sound- Understanding the Physics of musical Sound was one of Raman's passions. The Sensations of Tone by Hermann Von Helmholtz, which he came across when he entered IACS, inspired him. Between 1916 and 1921, he researched and published a lot of his observations. Based on the superposition of velocities, he developed the principle of transverse vibration of bowed string instruments. The wolf tone in violins and cellos was one of his earliest experiments. He investigated the acoustics of various violins and related instruments, as well as water splashes and Indian stringed instruments. "Experiments with mechanically-played violins" was one of his works. C V Raman Discovery behind the Blue colour of the sea- In 1919, Raman began investigating light scattering as part of his broadening foray into optics. His first amazing discovery was the mechanics of seawater's blue colour. In September 1921, he reflected on the Mediterranean Sea's blue colour while sailing home from England on the S.S. Narkunda. He tested the seawater with basic optical instruments, including a pocket-sized spectroscope and a Nicol prism. No.56 Lord Rayleigh's explanation in 1910, "The much-revered dark blue of the deep sea has little to do with the colour of water, but is the blue of the sky seen by refraction," was the strongest of many theories on the colour of the sea. C V Raman Inventions: Most photons

are elastically dispersed as light is scattered from an atom or molecule. The incident photons have the same energy (frequency) as scattered photons, and therefore the same wavelength. Excitations of optical frequencies distinct from, and normally lower than, the frequency of the incident photons scatter a small fraction of scattered light (roughly one in ten million photons). Raman scattering may occur in gas when a molecule's vibrational, rotational, or electronic energy changes. "The character of scattered radiations allows us to obtain an insight into the ultimate structure of the scattering," Raman explained. Raman published his thesis on "Molecular Diffraction of Light" in 1922, the first of a series of investigations with his collaborators that eventually led to his discovery of the radiation effect that bears his name (on February 28, 1928).

In 1928, C. V. Raman and K. S. Krishnan, as well as Grigory Landsberg and Leonid Mandelstam, independently identified the Raman effect. Raman's discovery was hailed by physicists as evidence of the quantum theory. The vibrational Raman effect is of primary interest to chemists. The Raman Effect was named a National Historic Chemical Landmark by the American Chemical Society in 1998, in recognition of its importance as a method for studying the structure of liquids, gases, and solids. The Raman Effect is distinct from the fluorescence mechanism. The incident light is completely absorbed in the latter case, and the system is transferred to an energetically excited state from which it can only transition to various lower states after a certain period (resonance lifetime). Both processes emit a photon with a different frequency than the incident photon, and the molecule is brought to a higher or lower energy level. However, the Raman Effect can occur for any frequency of incident light, which is a significant difference. The Raman Effect, in contrast to the fluorescence effect, is not a resonant effect.

CV Raman's Achievements

Many honorary doctorates and memberships in scientific societies were bestowed upon Raman. He was a member of the Deutsche Akademie in Munich, the Swiss Physical Society in Zurich, the Royal Philosophical Society in Glasgow, the Royal Irish Academy, the Hungarian Academy of Sciences, the Academy of Sciences of The Soviet Union, the Optical Society of America, and the Mineralogical Society of America, the Romanian Academy of Sciences, the Catgut Acoustical Society of America, and the Czechoslovak Academy of Sciences. He was elected a Fellow of the Royal Society in 1924. He did, however, resign from the fellowship in 1968 for unknown reasons, making him the only Indian FRS to do so. In 1929, he was the President of the Indian Science Congress's 16th session. From 1933 until his

death, he was the first President of the Indian Academy of Sciences. In 1961, he was elected to the Pontifical Academy of Sciences.

Awards

Though still employed by the Indian Finance Service, Raman won the Curzon Research Award in 1912. While still working for the Indian Finance Service, he received the Woodburn Research Medal in 1913. The Accademia Nazionale delle Scienze in Rome awarded him the Matteucci Medal in 1928. He was knighted in 1930. The Viceroy of India, Lord Irwin, conferred him a Knight Bachelor in a special ceremony at the Viceroy's House (now Rashtrapati Bhavan) in New Delhi after his inclusion in the 1929 Birthday was postponed. He was awarded the Nobel Prize in Physics in 1930 for "research on light scattering and the discovery of the phenomenon named after him." He was the first Asian and non-white person to win a Nobel Prize for Science. Rabindranath Tagore (another Indian) had previously won the Nobel Prize for Literature in 1913. He was awarded the Hughes Medal of the Royal Society in 1930. The Franklin Institute in Philadelphia awarded him the Franklin Medal in 1941. He received the Bharat Ratna award in 1954. (along with politician and former Governor-General of India C. Rajagopalachari and philosopher Sir Sarvapalli Radhakrishnan). He received the Lenin Peace Prize in 1957.



Raman with spectrograph and Raman Tube

Sir CV Raman

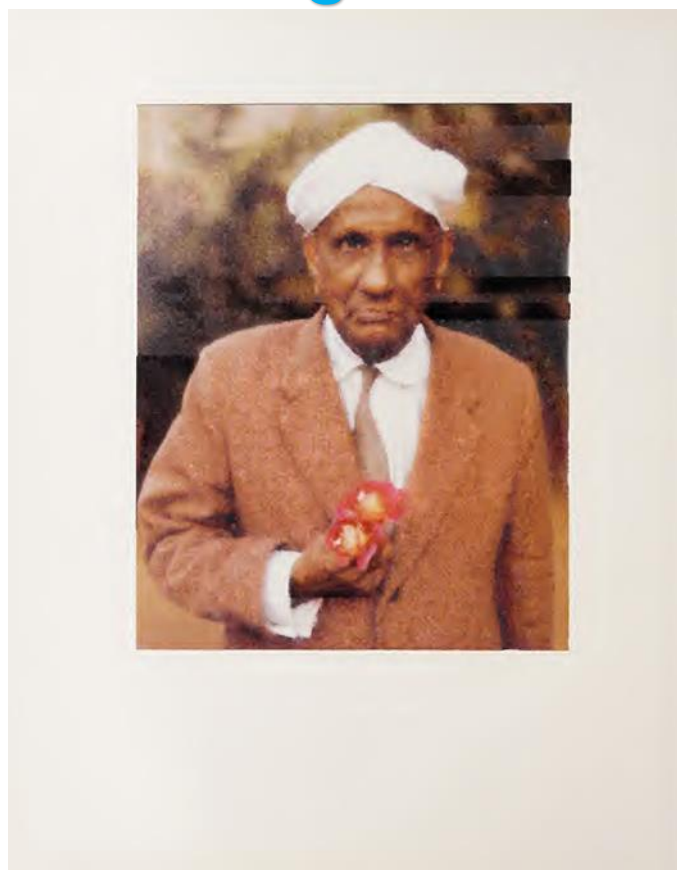
A Pictorial Biography

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Chandrasekhara Venkata Raman
1888 -1970

THE LAST PHOTOGRAPH

Preface

This is both a preface and an acknowledgement. The origin of the pictures reproduced in this volume goes back to the golden jubilee of the Raman Effect in 1978 which was celebrated by an International Conference on Raman Spectroscopy in Bangalore. For that occasion, it was suggested that I should put together an exhibition of pictures related to Raman's history. I wrote to a large number of people, many of whom to my great satisfaction responded by sending me numerous photographs. Most of these were only snapshots but they covered the period and incidents which one desired to portray in the exhibition. Mr C Rajagopal, one of our best-known photographers, and his team at the National Aeronautical Laboratory, with the enthusiastic support of its Director, Dr SR Valluri, proceeded to copy and enlarge these pictures. Thanks to the help of Prof. G Srinivasan of the Raman Research Institute, these pictures were mounted to create an exhibition that was a major attraction during the conference and was much appreciated by the visiting delegates.

When the Raman Centenary Symposium was being planned it was suggested that a volume could be produced containing these pictures which would serve both as a permanent record and also be available to a larger group. But inexplicably, the negatives and the original photographs were "discovered" to have been lost, and the only way was to rephotograph the pictures that had been produced for the 1978 exhibition. This was undertaken by Mr C Ramachandra Rao the Staff Photographer of the Raman Research Institute, who managed to do a remarkable job as witness the pictures reproduced in this volume. Also included are some pictures in colour taken by him of some of the gems, minerals, shells, birds, butterflies and other colourful manifestations of Nature from the Raman collection.

What is unfortunate, however, is that all of the information regarding the original donors was lost. I am in the embarrassing

position of not being able to acknowledge by name all those who were originally responsible for providing the material reproduced here. In fact this collection is the source from which material has been provided for any number of publications, books, films, videos, etc., relating to Raman and produced in recent years. May I record my heartfelt thanks to those now anonymous donors.

Finally, I would like to thank Mr MS Chintamani of the Eastern Press who was largely responsible for persuading me that a book such as this would be most appropriate to produce the occasion of the Raman Centenary. Also, we owe to his personal interest, ability and care, the fine quality of this production.

It is said, and with reason, that one picture is worth a thousand words, and it is hoped that the pictures reproduced here will speak that eloquently. Even so I have been persuaded that it would add to the value of this volume if some written accounts were included at the beginning and the end to provide information relevant to Raman's history. The four articles the beginning (all written versions of talks I gave) deal more with his life, career and style than with his science. At the end are reproduced the prefaces to the six volumes of Raman's collected scientific papers that were put together and published also in connection with the centenary. In these may be found an attempt to indicate in brief the range and content of the prodigious contributions of the remarkable scientist that was Raman. Pictures cannot convey this aspect of the man. And these prefaces are included only to whet the appetite for the repast that awaits any reader of his original works.



S Ramaseshan

It is highly recommended that the readers to visit the given site below to read the FULL book:

<https://archive.org/details/cvramanpictorial00banq>

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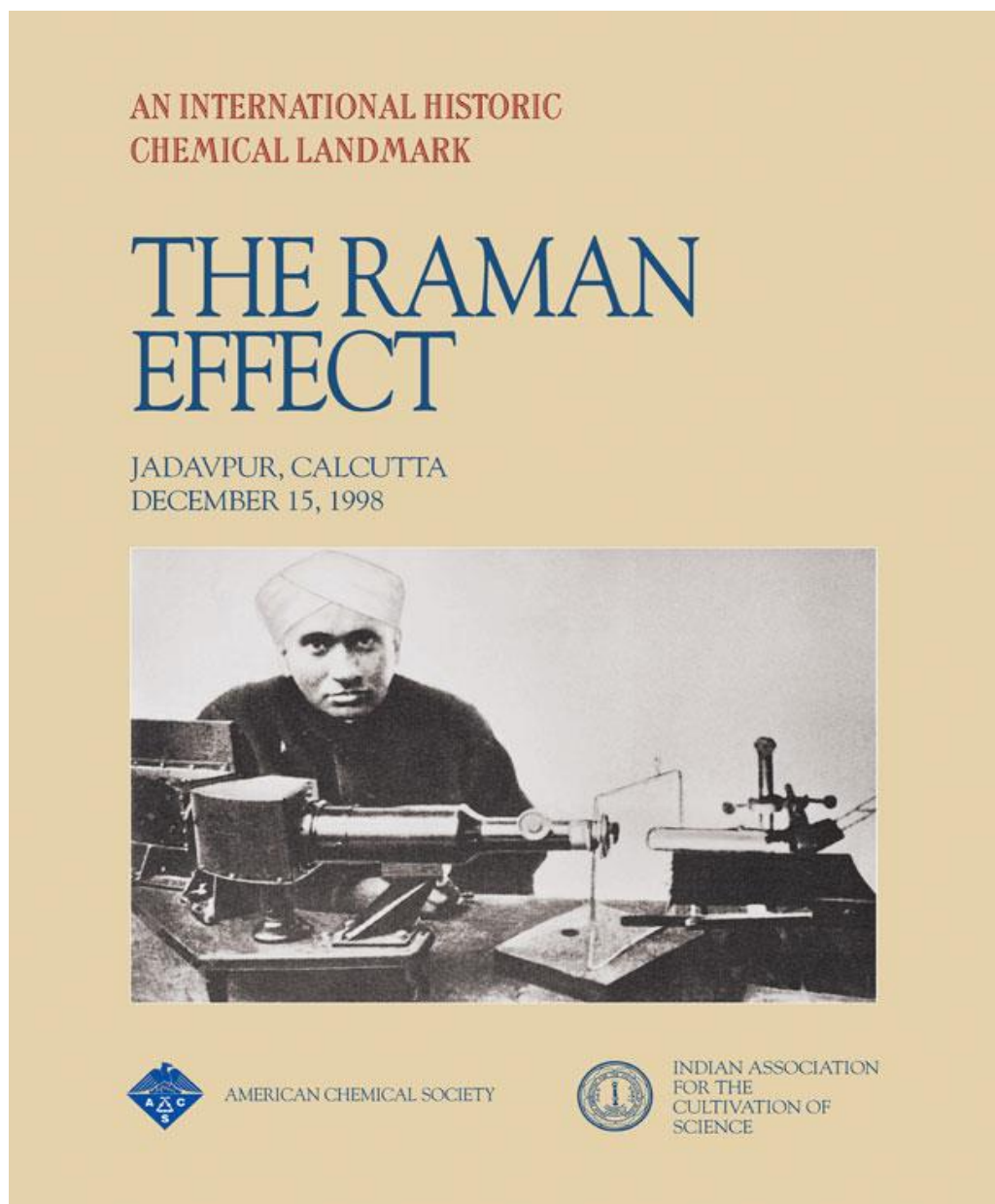
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The Raman Effect

Commemorative Booklet (PDF)



"The Raman Effect" commemorative booklet produced by the National Historic Chemical Landmarks program of the American Chemical Society in 1998 (PDF).

<https://www.acs.org/education/whatischemistry/landmarks/ramaneffect.html>

"I propose this evening to speak to you on a new kind of radiation or light emission from atoms and molecules." With these prophetic words, Professor C. V. Raman of Calcutta University began his lecture to the South Indian Science Association in Bangalore on March 16, 1928. Raman proceeded to describe a discovery that resulted from a deceptively simple experiment. Conducted far from the great centers of scientific research in the Western world, the results would capture the attention of scientists around the world and bring many accolades, including the Nobel Prize, to their discoverer.

CONTENTS

Raman's Fascination with Light Scattering

Educated entirely in India, C.V. Raman made his first trip to London in 1921, where his reputation in the study of optics and especially acoustics was already known to the English physicists J. J. Thomson and Lord Rutherford, who gave him a warm reception. Raman's specialty had been the study of the vibrations and sounds of stringed instruments such as the violin, the Indian veena and tambura, and two uniquely Indian percussion instruments, the tabla and the mridangam.

But it was the return trip from London to Bombay aboard the SS Narkunda that would change forever the direction of Raman's future. During the fifteen-day voyage, his restless and probing mind became fascinated with the deep blue color of the Mediterranean. Unable to accept Lord Rayleigh's explanation that the color of the sea was just a reflection of the color of the sky, Raman proceeded to outline his thoughts on the matter while still at sea and sent a letter to the editors of the journal *Nature* when the ship docked in Bombay.

A short time later Raman was able to show conclusively that the color of the sea was the result of the scattering of sunlight by the water molecules. Ironically, it was exactly the same argument that Rayleigh had invoked when explaining the color of the sky — the blue was the result of the scattering of sunlight by the molecules in the air.

Raman was now obsessed with the phenomenon of light scattering. His group in Calcutta began an extensive series of measurements of light scattered primarily by liquids but also by some solids. As a result, Raman was able to explain the blue color observed in the ice of Alpine glaciers.

Raman Measures the Effect of Light Scattering

Analysis of light scattered by a liquid is not an easy task, and much of the early work in Calcutta was done by the visual observation of color rather than precise measurements of the light's wavelength as shown in Figure 1 at right. The fundamentals of Raman's crucial experiment are outlined in Figure 2.

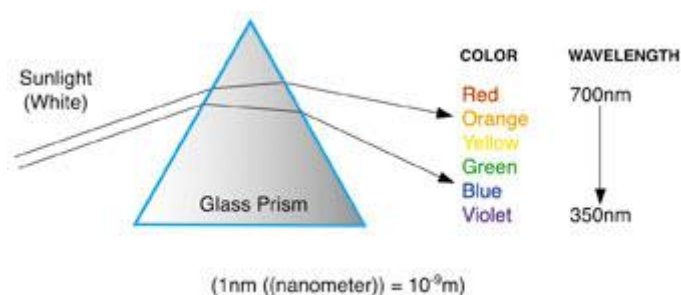


Figure - 1

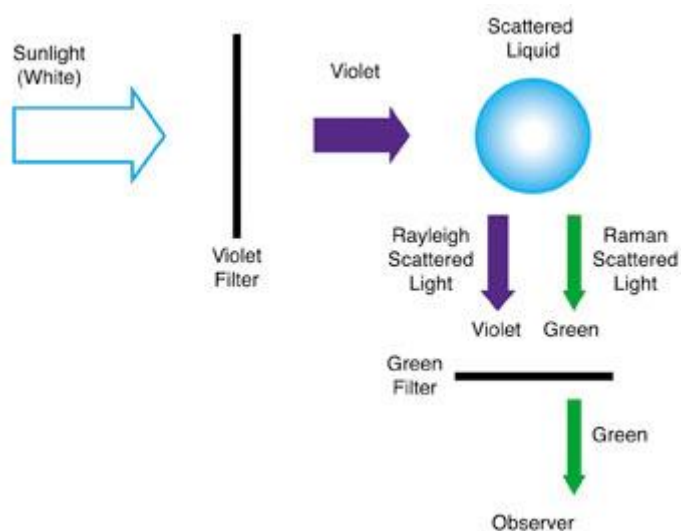


Figure - 2

The violet light of the solar spectrum is isolated with a violet filter and passed through the liquid sample. Most of the light emerging from the liquid sample is the same color as the incident violet beam: the so-called Rayleigh scattered light. However, Raman and K. S. Krishnan were able to show that some of the scattered light was a different

color, which they could isolate by using a green filter placed between the observer and the sample. The advantage of using a visual observation is that several substances can be studied quickly. In his first report to *Nature*, titled "A New Type of Secondary Radiation," Raman indicated that approximately 60 different liquids had been studied, and all showed the same result — some scattered light had a different color than the incident light. "It is thus," Raman said, "a phenomenon whose universal nature has to be recognized."

The Raman Effect is a very weak effect; only one in a million of the scattered light particles, or photons, actually exhibits the change in wavelength. This explains, in part, why the effect was not discovered earlier. In all of the early light-scattering studies, the excitation source was sunlight, which Raman has described as being plentiful in Calcutta, but it still lacked the desired intensity. The acquisition in 1927 by the IACS of a seven-inch (18 cm) refracting telescope enabled Raman to condense the sunlight and create a more powerful light source for his studies. By early 1928, mercury arc lamps were commercially available, and he switched to this even more intense light source.

Raman knew that visual and qualitative observations alone would not be sufficient information. He methodically set out to measure the exact wavelengths of the incident and Raman scattering by replacing the observer with a pocket spectroscope. He ultimately replaced it with a quartz spectrograph with which he could photograph the spectrum of the scattered light and measure its wavelength. These quantitative results were first published in the *Indian Journal of Physics* on March 31, 1928.

Raman Effect as the Physicist's Tool

The significance of the Raman Effect was recognized quickly by other scientists. Professor R. W. Wood of Johns Hopkins cabled *Nature* to report that he had verified Raman's "brilliant and surprising discovery ... in every particular. It appears to me that this very beautiful discovery which resulted from Raman's long and patient study of the phenomenon of light scattering is one of the most convincing proofs of the quantum theory."



Although Raman's original experiments were done by visual observation, precise measurements were made with this quartz spectrograph and first made public by Raman in a lecture in Bangalore on March 16, 1928.

Courtesy the Indian Association for the Cultivation of Science.

Raman had also recognized that his discovery was important to the debate in physics over the new quantum theory, because an explanation of the new radiation required the use of photons and their change in energy as they interacted with the atoms in a particular molecule. Raman also knew that there was a more important result, remarking in his 1930 Nobel Prize address that "... the character of the scattered radiations enables us to obtain an insight into the ultimate structure of the scattering substance."

In the first seven years after its discovery, the Raman Effect was the subject of more than 700 papers in the scientific literature, mostly by physicists who were using the technique to study the vibration and rotation of molecules and relating those phenomena to the molecular structure. Then, as noted by Raman biographer G. Venkataraman, there was a decline in interest, as "the first bloom of novelty had worn off and physicists were satisfied that they understood the origin of the effect." At the same time, chemists became interested in the Raman Effect as an analytical tool. In James Hibben's words, "The Raman Effect became the adopted child of chemistry."

Raman Effect as a Chemist's Tool

By the late 1930s the Raman Effect had become the principal method of nondestructive chemical analysis for both organic and inorganic compounds. The unique spectrum of Raman scattered light for any particular substance served as a "fingerprint" that could be used for qualitative analysis, even in a mixture of materials. Further, the intensity of the spectral lines was related to the amount of the substance. Raman spectroscopy could be applied not only to liquids but also to gases and solids.

And unlike many other analytical methods, it could be applied easily to the analysis of aqueous solutions. It was a ubiquitous technique, giving information on what and how much was present in a plethora of samples.

The use of Raman spectroscopy as a basic analytical tool changed sharply after World War II. During the war, infrared spectroscopy was enhanced by the development of sensitive detectors and advances in electronics. Infrared measurements quickly became routine operations, while Raman measurements still required skilled operators and darkroom facilities.

Raman spectroscopy could no longer compete with infrared until another development in physics — the laser — revived Raman spectroscopy in a new form beginning in the 1960s.

The Laser and Raman Spectroscopy

Raman understood the need for more intense light sources to amplify the effect and observation of the scattered light. The laser provided an even more intense source of light that not only could serve as a probe exploring the properties of the molecule but could also induce dramatically new effects.

With the development of the Fourier transform (FT) technique and the application of computers for data handling, commercial FT-Raman spectrometers became available in the late 1980s, resulting in resurgence in the use of the original Raman Effect.

The new Raman spectroscopy has been used to monitor manufacturing processes in the petrochemical and pharmaceutical industries. Illegal drugs captured at a crime scene can be analyzed rapidly without breaking the evidence seal on the plastic bag. Chemists can watch paint dry and understand what reactions are occurring as the paint hardens. Using a fiber-optic probe, they can analyze nuclear waste material from a safe distance. Photochemists and photobiologists are using laser Raman techniques to record the spectra of transient chemical species with lifetimes as small as 10^{-11} seconds. Surface-enhanced Raman spectroscopy is used for studying surfaces and reactions on surfaces. And, according to Kathy Kincade, Raman spectroscopy

"has the ability to provide specific biochemical information that may foreshadow the onset of cancer and other life-threatening illnesses."

In his 1928 talk in Bangalore, Raman concluded, "We are obviously only at the fringe of a fascinating new region of experimental research which promises to throw light on diverse problems relating to radiation and wave theory, X-ray optics, atomic and molecular spectra, fluorescence and scattering, thermodynamics, and chemistry. It all remains to be worked out."

Seventy years later scientists are still actively working out the results and practical applications of Raman's deceptively simple experiment.

Biography of Sir C.V. Raman

According to Hindu tradition, Raman was originally named Venkataraman after a Hindu deity, preceded by the initial of his father's first name, Chandrasekhara. In school his name was split to C. Venkata Raman, which later became C.V. Raman. With a father who was a professor of physics and mathematics and a mother who came from a family of Sanskrit scholars, Raman exhibited a precocious nature at an early age. He received a B.A. degree from Presidency College in Madras at the age of 16, placing first in his class and receiving a gold medal in physics.

While studying for his M.A. degree, he published his first research paper in *Philosophical Magazine* at the age of 18. It was the first research paper ever published from Presidency College.

Because of poor health, he was unable to go to England for further education. With nothing else available in India, in 1907 he passed the Financial Civil Service exam, married, and was posted to Calcutta as assistant accountant general.

Shortly after arriving in Calcutta, Raman began after-hours research at the Indian Association for the Cultivation of Science (IACS). In the first 10 years, working almost alone, he published 27 research papers and led the way for the IACS to become recognized as a vibrant research institute. Much of this early work was on the theory of vibrations as it related to musical instruments. After brief postings in Rangoon and

Nagpur, he returned to Calcutta, took up residence next door to the IACS, and constructed a door that led directly into the institute, giving him access at any time. He received research prizes in 1912 and 1913 while he was still a full-time civil servant. He also increased the IACS reputation with his extensive lectures in popular science, holding the audience spellbound with his booming voice, lively demonstrations, superb diction and rich humor.

At the age of 29 he resigned from his lucrative civil service job when Sir Ashutosh Mukherjee, vice-chancellor, Calcutta University, offered him the Palit Chair Professorship. He continued to lecture even though it was not required, and he used the IACS as the research arm of the university. By the time of his first visit to England in 1921, his reputation in physics was well known. Three years later he was elected a Fellow of the Royal Society — only the fourth Indian so honored. That same year he toured the United States, spending four months at the California Institute of Technology through the invitation of Nobel Laureate Robert Millikan.

After discovering the Raman Effect in 1928, he was knighted by the British government in India and received the Nobel Prize in physics in 1930. Three years later, Raman left Calcutta for Bangalore, where he served as head of the Indian Institute of Science. There he continued his work on the Raman Effect and became interested in the structure of crystals, especially diamond. In 1934 he founded the Indian Academy of Science and began the publication of its *Proceedings*.

In 1948 he became director of the newly constructed Raman Research Institute, where he remained continually active, delivering his last lecture just two weeks before his death. His research interests changed in later years when he primarily investigated the perception of color.

Jagdish Mehra, a biographer, states, "Educated entirely in India, Raman did outstanding work at a time when the small Indian community worked almost entirely in isolation and few made science a career. In fostering Indian science, Raman emerged as one of the heroes of the Indian political and cultural renaissance, along with ... Mahatma Gandhi and Jawaharlal Nehru." But as Raman himself once said,

outstanding investigators "are claimed as nationals by one or another of many different countries. Yet in the truest sense they belong to the whole world."

LANDMARK DESIGNATION AND ACKNOWLEDGMENTS

Landmark Designation

The American Chemical Society and the Indian Association for the Cultivation of Science dedicated The Raman Effect an International Historic Chemical Landmark on December 15, 1998 at the Indian Association for the Cultivation of Science in Jadavpur, Calcutta, India. The plaque commemorating the event reads:

At this institute, Sir C. V. Raman discovered in 1928 that when a beam of coloured light entered a liquid, a fraction of the light scattered by that liquid was of a different color. Raman showed that the nature of this scattered light was dependent on the type of sample present. Other scientists quickly understood the significance of this phenomenon as an analytical and research tool and called it the Raman Effect. This method became even more valuable with the advent of modern computers and lasers. Its current uses range from the non-destructive identification of minerals to the early detection of life-threatening diseases. For his discovery Raman was awarded the Nobel Prize in physics in 1930.

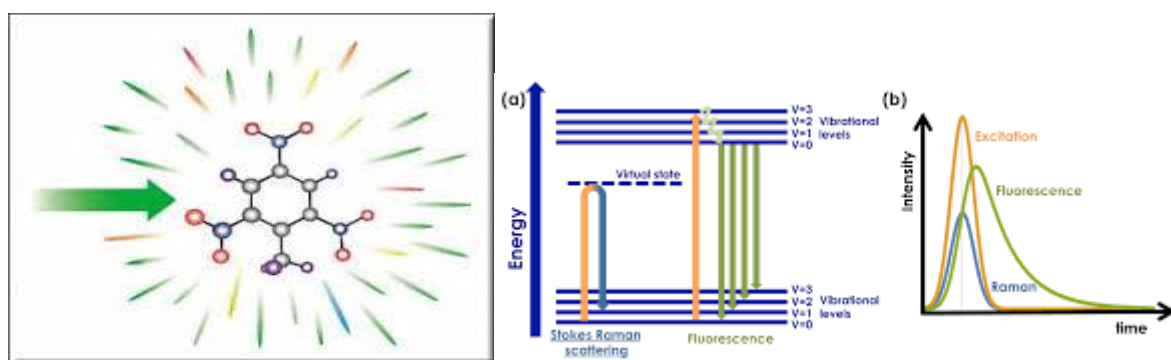
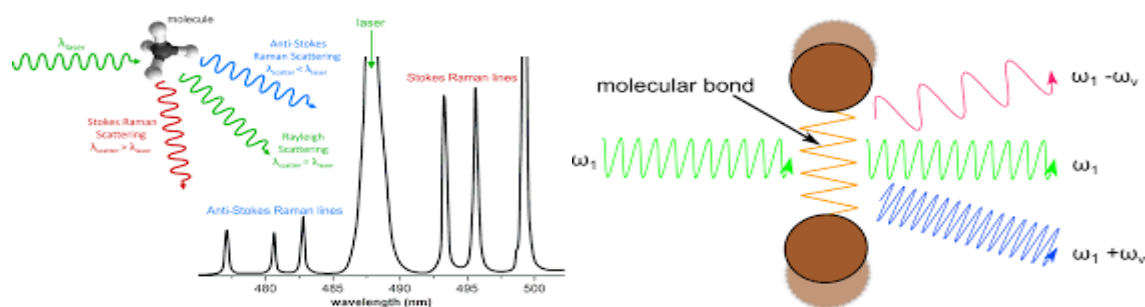
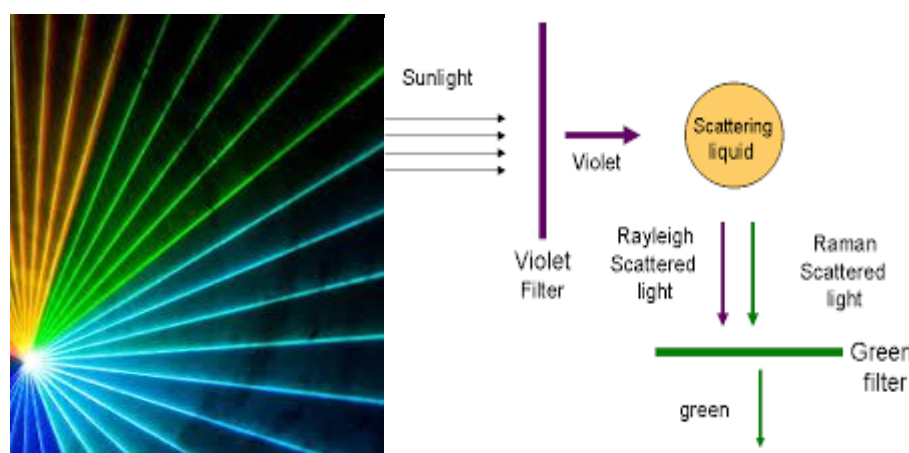
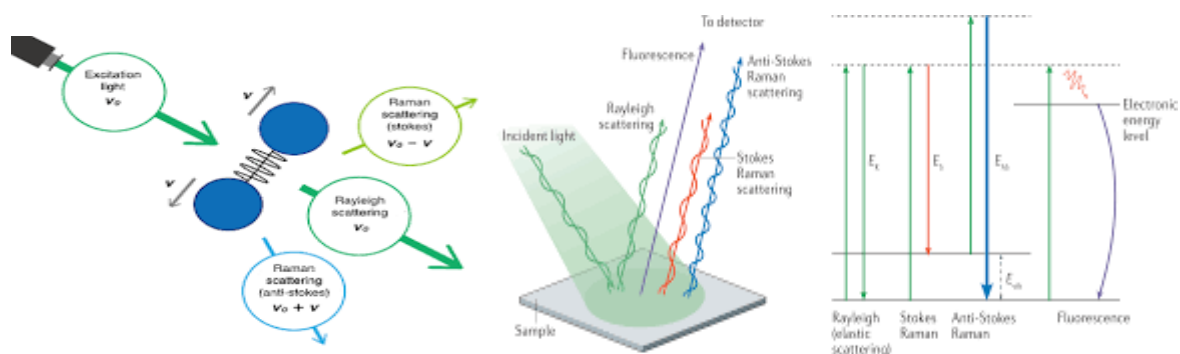
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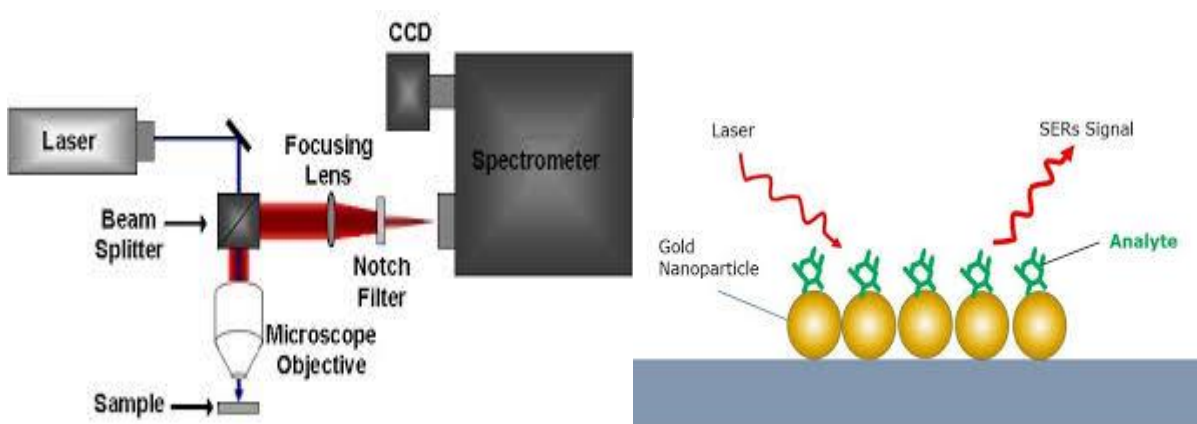
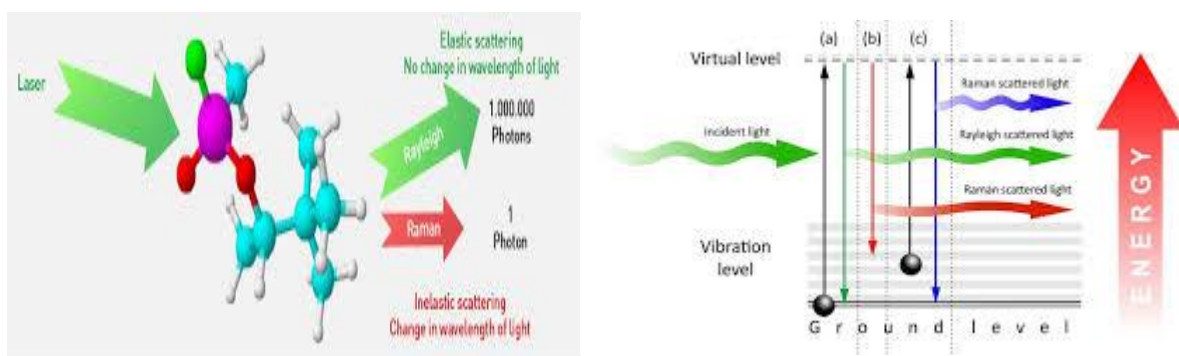
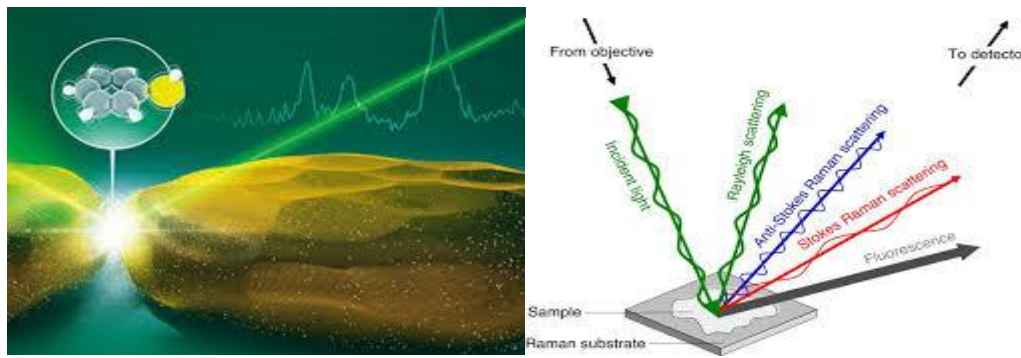
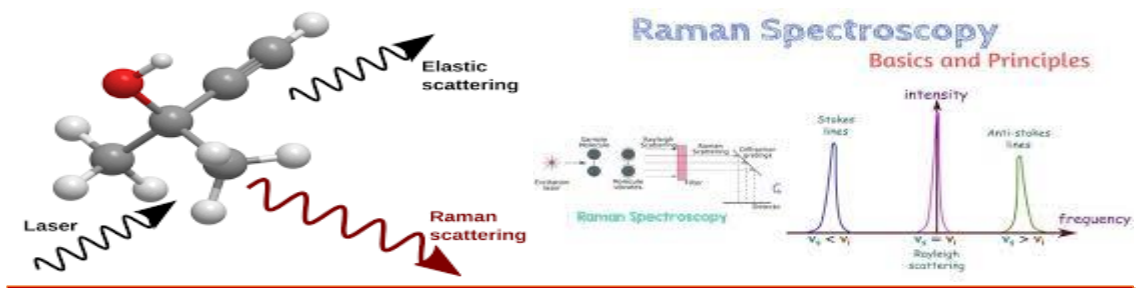
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A current model FT-Raman spectrometer.

RAMAN EFFECT IMAGES





Scientific Papers of CV Raman

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IV	Optics of Minerals and Diamond	76	774
V	Physics of Crystals	89	882
VI	Floral Colours and Visual Perception	85	642
Total		465	4170

Editor

S Ramaseshan

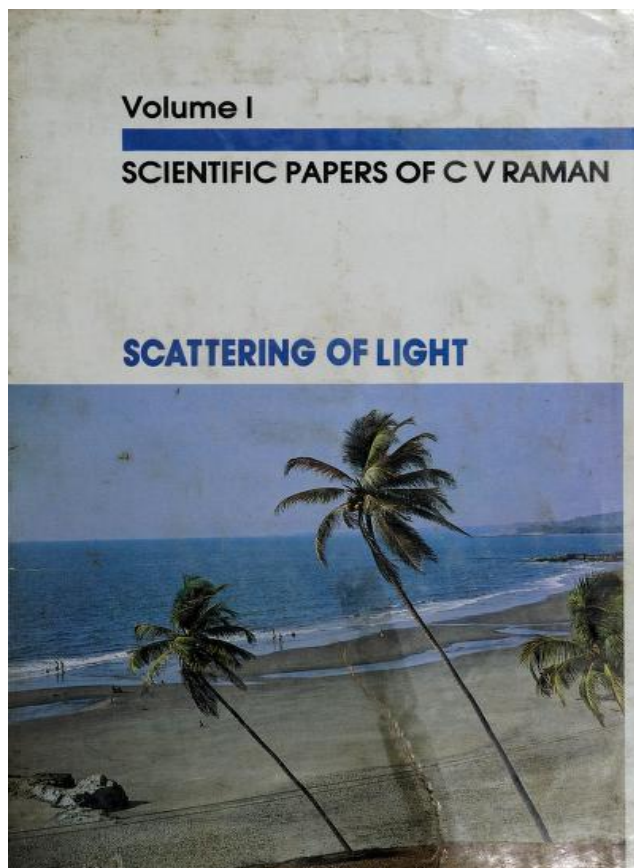
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Volume I : Scattering of Light



Editor

S Ramaseshan

Publisher

**INDIAN ACADEMY OF SCIENCES
BANGALORE**

C. V. Raman (1888-1970) was awarded the Nobel Prize for Physics in 1930 for the discovery of the Raman Effect, one of the most significant experimental discoveries of this century.

Volume I of the Scientific Papers of C V Raman contains 94 papers on Scattering of Light. They cover Molecular Scattering, Colloid Scattering, Raman Scattering, Brillouin Scattering and also X-ray and Compton Scattering. This volume also has in it the celebrated monograph Molecular Diffraction of Light (1922), the famous papers on The Colour of the Sea, the first lecture on the Raman Effect entitled "A New Radiation" (March 1928) and the Nobel Lecture delivered at Stockholm in 1930. The pioneering papers on optical and magnetic anisotropy and on magnetic, electric and flow birefringence are also to be found in this volume. Many are of historic value showing, for example, how Raman blazed new trails by discovering such new phenomena as shear waves in liquids and soft mode processes in crystals. A unique collection of papers by a master, delineating the growth of a fascinating field.

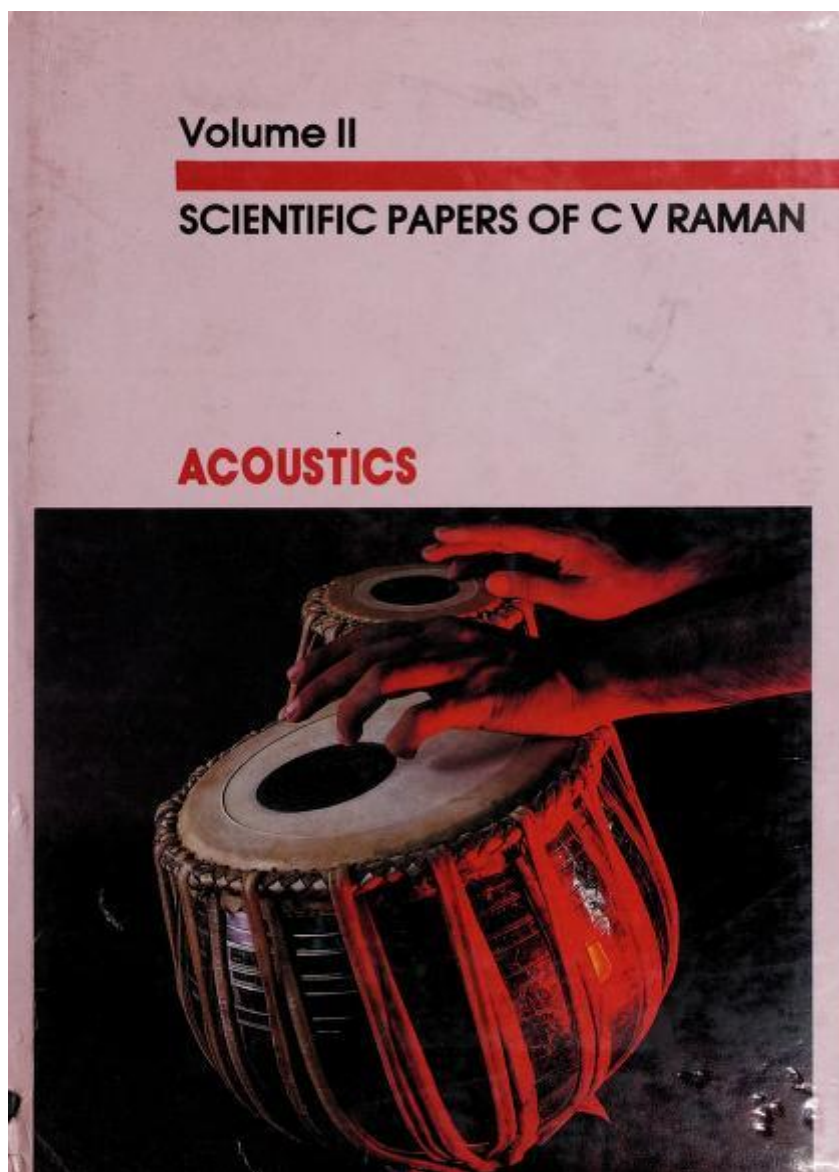
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Volume II: Acoustics



Editor

S Ramaseshan

Publisher

**INDIAN ACADEMY OF SCIENCES
BANGALORE**

C.V. Raman (1888-1970) was an acoustician par excellence. His work on the violin is considered a classic.

Volume II of the Scientific Papers of C V Raman contains 55 publications in the field of Acoustics. It has in it the famous landmark paper On The Mechanical Theory of Vibration of Bowed Strings - perhaps the most important contribution to the theory of the violin since Helmholtz, and also the English translation of his celebrated monograph 'Musik instrumente und ihre Klänge' (Musical instruments and their tones) in the Springer Encyclopaedia of Physics. The volume includes six remarkable papers on the acoustics of Indian musical instruments - the Mridangam and Tabla the only percussion instruments in the world which produce harmonic vibrations, and the Tanpura and Veena which appear to violate the Young-Helmholtz law in producing their range of harmonic vibrations. The book also contains the well-known series of papers by Raman and Nath on the Diffraction of Light by Ultrasonic Waves.

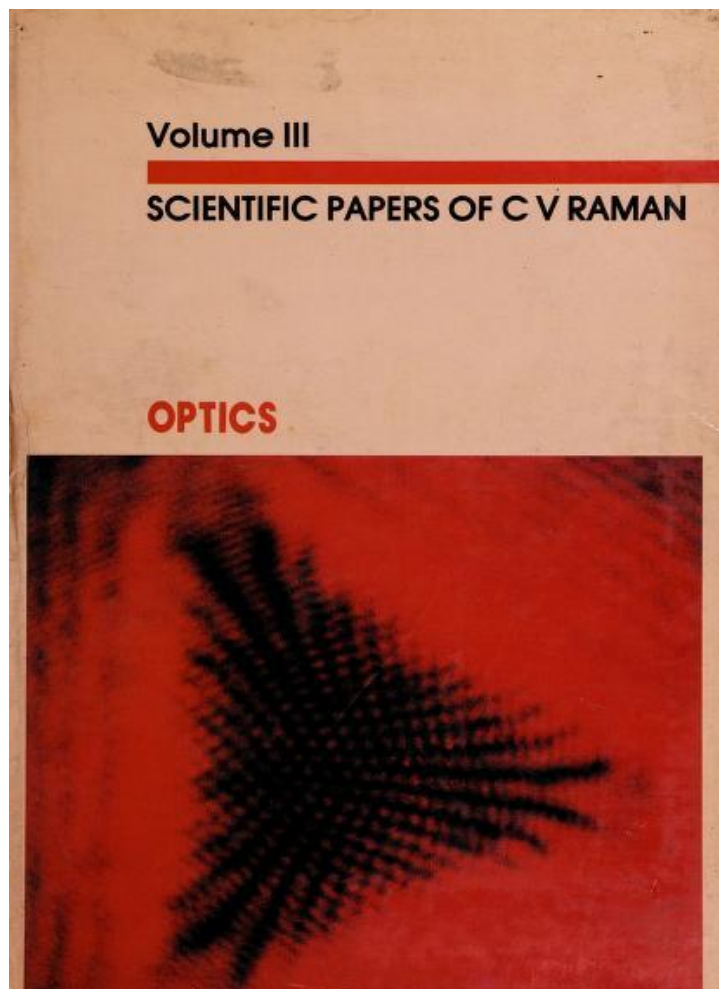
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Volume III: Optics



Editor

S Ramaseshan

Publisher

**INDIAN ACADEMY OF SCIENCES
BANGALORE**

C. V. Raman (1888-1970) who was awarded the Nobel Prize for Physics (1930) was a master in the field of optics.

Volume III of the Scientific Papers of C V Raman contains 63 of his publications in Optics. His celebrated Baroda Lectures (1941) reprinted here is a masterly elucidation of many optical phenomena reflecting forty years of living with light. Here may be found expositions on the geometric theory of Fresnel diffraction, the diffraction by a sphere and a circular disc, the study of haloes and coronae, and his discovery of the speckle phenomenon (1919) from observations of the radiant spectrum seen by the eye. The surprising observations on conical refraction, the wavelike character of periodic precipitates, the propagation of light in polycrystalline media, and the remarkable study of mirages of new relevance today in the context of cosmic mirages formed by gravitational lenses, are to be found in this collection.

This volume also has in it the celebrated Raman-Nath papers on the diffraction of light by ultrasonic waves introducing ideas which have found application decades later in many new fields like the dynamical theory of electron diffraction.

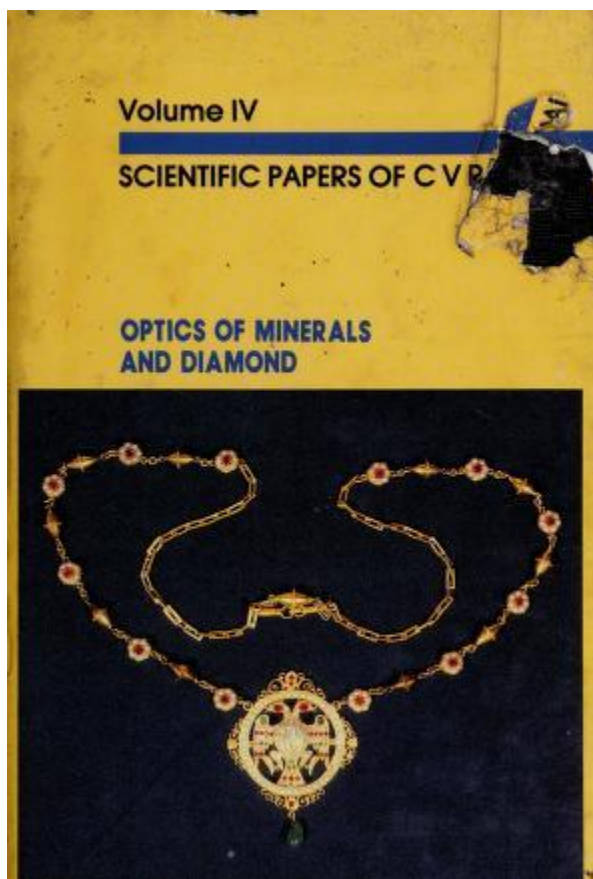
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Volume IV: Optics of Minerals and Diamond



Editor

S Ramaseshan

Publisher

**INDIAN ACADEMY OF SCIENCES
BANGALORE**

To C. V. Raman (1888 - 1970) colour in nature was an obsession. The visual impact that the blue of the Mediterranean had on him culminated in his discovery of the Raman effect. Volume IV of the Scientific Papers of C. V. Raman contains 79 papers he published on a variety of topics, 39 of which deal with colour in Nature. All the optical phenomena in his repertoire were necessary to explain the flashing rainbow colours of the plumage of birds. The hues of limestone and marble, the brilliant iridescence of feldspars of the labradorite variety, the pure spectral colours of the specular reflections from potassium chlorate, the schiller of the moonstones, fire of opals, and the silky lustre of the pearls which no lapidary can ever re-produce and hundred other topics are discussed in this volume. Raman was amongst the earliest to worry about what are now called periodic modulated structures.

Sixteen papers deal with diamonds. The beauty of their geometric form, and their lustrous curved faces, bring out clearly that many specimens exhibit a symmetry lower than the highest in the cubic class, Raman required an interplay and intermingling of these lower and higher symmetries to explain many properties like Raman activity, infra-red absorption, fluorescence, birefringence, X-ray topography etc. Raman therefore attributed a lower intrinsic symmetry to the carbon atom. But it was found much later that the real lowering of the symmetry was due to the presence of impurities. The papers deal with this very contagious subject.

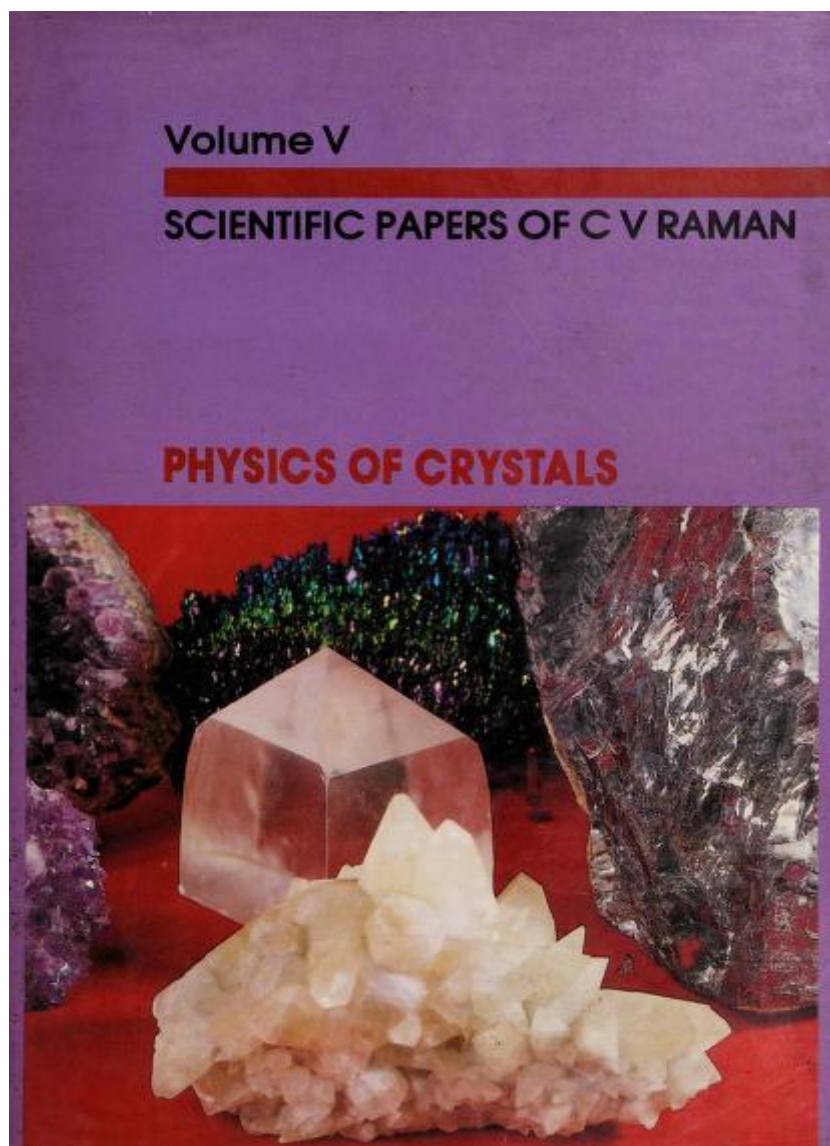
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Volume V: Physics of Crystals



Editor

S Ramaseshan

Publisher

**INDIAN ACADEMY OF SCIENCES
BANGALORE**

Volume V of the Scientific Papers of C.V.Raman contains the papers published by Raman on various aspects of crystal dynamics. The first set of papers relate to the experimental discovery by Raman and his collaborator of the thermal diffuse X-ray reflections as also the temperature-independent diffuse reflections which Raman thought were due to the interactions of X-rays with optical photons. There was much dispute about this interpretation of his experiments.

The next set of papers are on the theory of the dynamics of crystal lattices which was also the subject of a raging controversy. It must be said in this context that it was because of the persistence attack by the Raman School that Born's well-known lattice dynamics was re-examined. New physics came out and the concept of singularities emerged clearly. These studies finally showed that Raman's simple theory was a part of the more comprehensive Born theory.

The volume also contains a new view of the theory of elasticity developed by Raman and Viswanathan in which the symmetries of the stress and strain tensors and the number of independent elastic constants differed from the standard view. These papers also proved controversial.

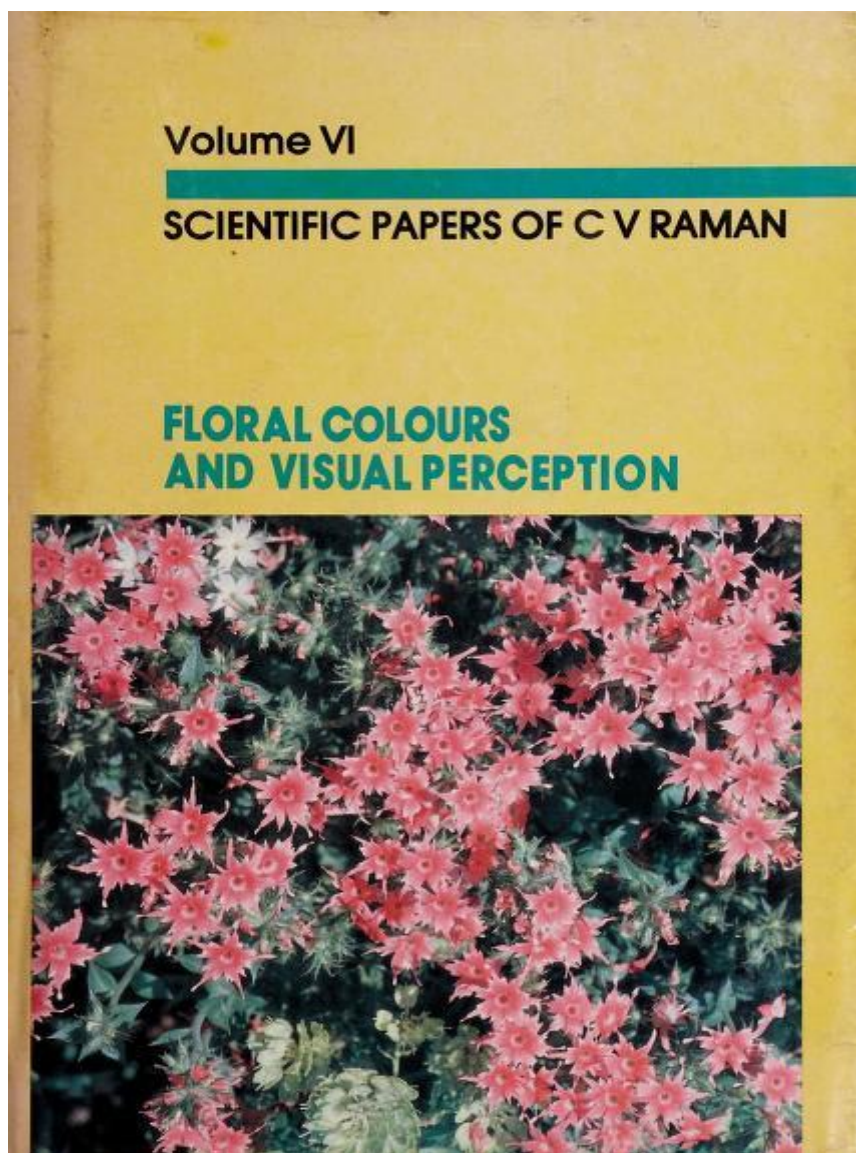
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Volume VI: Floral Colours and Visual Perception



Editor

S Ramaseshan

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Volume VI of the Scientific Papers of C. V. Raman contains the work Raman did in the last decade of his life. It also contains the charming monograph he wrote entitled the Physiology of Vision. Raman brings out the important point that the characteristics of human vision which play an important role in the perception of colour are as important in deciding a quality of a gem or a mineral as its optical properties. A simple method is given by which one could actually view one's own retina and explore its behaviour under various spectral excitations. Raman studies in detail the remarkable but not too widely known faculty of the unaided eye to recognise polarized light and also locate its plane of polarization. Raman investigates the incredible power of the eye to discriminate colours differing by as little as 10 Å. Raman is interested in the relationship of brightness and colour, particularly the colours of nebulae viewed through small and large telescopes. He describes simple demonstration experiments to measure the intensity at which colour perception is lost for different colours.

Raman deals with the possibility of a new type of twinkling of stars due to the statistics of photons striking the retina - and describes how to make these observations. Raman is amongst the earliest to set out in qualitative terms the presently accepted ideas on the conventional scintillation of stars as due to the corrugation of the incident wave front due to the atmosphere perturbation.

The book is full of simple experiments which can be set up and which illustrate many unforeseen aspects of the perception of light and colour.

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Sir CV Raman

A Memoir

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A line sketch of Raman by Homi Bhabha, 1949.

Chandrasekhara Venkata RAMAN

A. Jayaraman



Indian Academy of Sciences
Bengaluru 560 080

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Foreword

I am very happy that this book about Professor C.V. Raman, who founded the Indian Academy of Sciences in 1934, is being reprinted and republished by the Academy this year. The first edition of this book was published in 1988 by the Affiliated East-West Press and is now out of print. This edition has been entirely retyped and reformatted to take advantage of the changes in publishing methods in the past thirty years. I would like to record my sincere thanks to the President and the Staff of the Indian Academy of Sciences for taking a keen interest in reprinting this book. I am grateful to Mrs Dominique Radhakrishnan and the Raman Research Institute for permission to reproduce some of the new photographs that have

been included in this edition, and to Dr. Mohan Narayanan and Dr. Vinodh Narayanan for their help.

The Indian Academy of Sciences is the right conduit to propagate the spirit in which this book has been written: I hope that it will impress upon young minds (in India and elsewhere) that great discoveries are the results of a keen observation of Nature and the persistent pursuit to find the truth. Raman used very simple equipment to make several significant discoveries using sunlight, including the Raman Effect itself. After the advent of lasers a Raman spectrum can be simply recorded in a matter of minutes, but it was a major challenge in Raman's time. During his Calcutta years he turned to sunlight to carry out the light scattering experiments which culminated in the discovery of the Raman effect. Using a complementary set of dye filters, he isolated narrow regions of the Sun's spectrum and visually observed the very weak scattered light that had undergone a change in the frequency by interacting with molecules. Having seen with his own eyes that a very weak glow was separated by a dark band from the strong incident light, he employed a mercury arc lamp to confirm the nature of the very weak scattered light, namely that it consists of narrow lines, modified by the vibrating molecule. He has said many times that the cost of the equipment to make the discovery was a mere 500 Rupees of those times. I don't think many realize this - as well as the fact that it was scattered sunlight that gave him the first clue!

During the early years at the Raman Research Institute we did not have electricity for a long time – it took eighteen months to complete electrification after my joining, when I went to work with Raman. Undeterred by this disadvantage Raman asked me to direct a beam of sunlight reflected by a mirror from outside to do some beautiful work on optical phenomena exhibited by a class of mineral samples that he had collected for display in his Museum as well as for research. I did not realize at that time that the Raman effect was discovered using sunlight until one day he demonstrated it to me while we were doing other experiments.

Raman's was a very inspiring and colourful personality, and his contributions to science in India will last forever. I hope that this book captures these different aspects of Raman – the man and the scientist.

*A. Jayaraman
Phoenix, February 2017.*

Foreword

The lives of men and women who achieve great distinction in science, literature or art hold a great fascination for the general public. A creative accomplishment standing well above even superior excellence is awe-inspiring. Even great discoverers reach the height of creativity only a few times during their career; the intense emotion then felt by them is best illustrated by story of Archimedes running through the streets of Syracuse shouting "Eureka"!

The contemporary style of scientific reporting, as it has evolved, however, leaves out much of the drama — the initial inspiration, the feverish pursuit, the false trails and frustrations, and, finally, the ecstasy of discovery. Even the presentation of scientific controversies in the professional journals is subdued, thanks to alert editors! The excitement of scientific research, the colourful persons who populate the scientific community, the clash of personalities — all of these are carefully excluded from published literature, only to become a part of scientific folklore. Biographies of great personalities in science are, therefore, all the more precious documents. When written by their contemporaries, especially if by one of their close associates, they are invaluable.

Sir C.V. Raman, the discoverer of the Raman effect, made numerous innovative and original contributions to modern physics, optics and acoustics during the first half of this century. By his scientific accomplishments and by his unique scientific leadership in modern India, he made a profound impact. Dr. A. Jayaraman, a condensed matter physicist internationally known for his pioneering contributions to the physics of matter subjected to ultra-high pressures, was closely associated with Raman when he founded the Raman Research Institute in 1949 and developed it into a great centre of research.

For over eleven years, Jayaraman had the opportunity to interact with Raman on almost a daily basis and observe his scientific style, philosophy and motivations. We thus have here an authoritative biography of the most unique scientific personality of modern India, written with genuine understanding and admiration but with critical judgment and honesty which do not avoid the discussion of the all too human limitations of a great man. The result is an authentic narration from a person who knows his subject. Jayaraman has enriched the history of science by writing this biography.

*A.K. Ramdas Professor of Physics
Purdue University*

Preface

Professor C.V. Raman was the most outstanding scientist that India gave the world. He not only became famous for his work but put India on the scientific map. He was a very colourful personality and a brilliant spokesman for science in India. Despite the great disadvantages, namely the lack of a tradition for research in the country, the very little encouragement he received for pursuing a scientific career and the meagre equipment available, Raman rose to the pinnacle of science and eminence. He gave up a lucrative Government job, to take up a Professorship that offered a fraction of the salary, only to advance his career as a scientist. His reward was the Nobel Prize for physics that was awarded to him in 1930 for his discovery of the light-scattering effect named after him.

He was a towering and dynamic scientific leader who inspired generations of students he trained in the methodology of research. He created the school of physics in Calcutta first, and then in Bangalore. His disciples came from all parts of India. He kindled their scientific interest and curiosity, and communicated to them the scientific spirit and the joy of scientific research. Many of his students and associates became in their lifetimes leaders of science and, in turn, created their own schools of research.

Raman was a brilliant and powerful speaker and his lectures, often with demonstrations, were a treat to listen to. A listener could never forget the exciting way in which he expounded a subject and the enthusiasm he generated. He wrote his scientific papers with meticulous care and often used Latin expressions to emphasise a point. His flow and style of English were extraordinarily lucid; reading his scientific memoirs is like reading a piece of literary exposition.

He founded several scientific journals and nurtured them with care, for he believed that the quality of work and the quality of a journal go together. He published most of his scientific papers in these journals and encouraged his students and coworkers to do the same. He founded a Science Academy in Bangalore to serve as a forum for discussing scientific results and disseminating scientific knowledge through meetings, lectures and publications, by the Fellows of the Academy and their associates. He took a keen interest in the affairs of the Academy and got promising young scientists elected to the Fellowship of the Academy, long before they reached the peaks in their career. He could recognise talent and merit instinctively.

After his formal retirement from the Indian Institute of Science he founded the Raman Research Institute to pursue his scientific interests, for retirement from scientific work was inconceivable for

Raman. The pursuit of science was the most joyous experience for him; it was the breath of his life. His scientific interests spanned subjects ranging from physics to biology and he could be truly called a Natural Philosopher, a vanishing breed in these days of extreme specialisation.

Raman was fiercely independent in thought and action and fearless in expressing his views. He was respected and honoured by maharajahas, princes, politicians and the general public. The mention of the name Sir C.V. Raman evoked respect and admiration everywhere in India.

Raman had a finely honed aesthetic sense and loved Nature. He loved colour, wherever it was found, in trees, gardens, flowers, sunsets, mountains and lakes. He was very curious about Nature and natural phenomena. If a subject interested him, he went into it deeply without any preconceived ideas. He would question all previously held views and reject them if they proved contrary to his experience. He had the gift of being able to reduce complex problems to simple and fundamental propositions. He often used to remark that a researcher should get to the wood and not be lost in the foliage. Raman was an experimentalist *par excellence*. In the understanding of physical phenomena, his physical intuition often leaped several steps over mathematics.

Raman was kind and generous to his associates and students. He was quick to express appreciation of good work and also to give tremendous encouragement at the right time. But he was also a man of strong emotions and could get violently angry, when provoked. In life he had fought many battles, both scientific and non-scientific. He had to face very difficult situations, but he never gave up hope, rejuvenating himself by immersion in scientific work.

What motivated Raman to do the extraordinary things he did against all odds? What was the secret of his success? These are questions to which there can be no simple answers. In fact, there will be as many answers as there are minds that ponder over such questions. But the events and course of his life are there, as facts, to examine, to marvel at and, perhaps, to provide a glimpse of understanding.

I had the greatest good fortune to be associated with him for eleven years, from 1949 to 1960, and moved closely with him, on a day to day basis. He was very kind and generous to me and trusted me very much. In fact, he treated me like his son, sharing his views, his ideas and his dreams. For me, this was a period of great education and experience and I owe my whole scientific career to him.

There are only a few biographical sketches on Raman — very few in fact — including a recent one by G. Venkataraman. I thought

a first-hand account of Raman and his life would be of interest to and, perhaps, inspire, some young aspirants to a career in Science. My account is, therefore, highly personalised, contains a lot of anecdotes and has been written with a lay reader (with some interest in Science) in mind. I have tried to cover the entire life of Raman to make this memoir complete. But because of my association with Raman in the later period, it may seem that I have devoted more pages to this period. My justification is that you get a more complete view of a person only from the vantage point of proximity. I, however, did not keep any diary and, hence, most of this account is from memory.

In writing this memoir, I have used material from the following: (1) An extraordinarily interesting and lucid account of Raman by the late Dr. L.A. Ramdas in two articles published in the *Indian Journal of Physics Education* in 1971; (2) A concise but authentic and accurate biographical sketch on Raman by Prof. S. Bhagavantam, published by the Andhra Pradesh Academy of Sciences, Hyderabad; (3) Extracts from the Indian Academy of Sciences' publication in 1984 entitled *The First Fifty Years*; (4) Extracts from Prof. S. Ramaseshan's articles and lecture, 'C.V. Raman Memorial Lecture' given at the Indian Institute of Science, Bangalore, and from *C.V. Raman and the German Connection*, an article written on the occasion of the Silver Jubilee of the Max Mueller Bhavan; (5) Extracts from the *Calcutta Municipal Gazette* dated July 4, 1931; (6) Extracts from the article on Sommerfeld's meeting with Raman in Calcutta in 1928, published by Dr. G. Torkar in the *Journal of Raman Spectroscopy*, 1986; (7) Extracts from the article *Golden Jubilee of the Discovery of the Raman Effect*, February 28, 1978, by the late Prof. K.R. Ramanathan in the Andhra Pradesh Academy of Sciences, Hyderabad; (8) Extracts from *Bhavan's Journal*, December 1970; (9) Extracts from the *Pasadena Star*, very kindly supplied by Paula Agranat Hurwitz of the California Institute of Technology Archives, Robert A. Millikan Memorial Library; and (10) Prof. B.S. Ramakrishna's articles on Indian Musical Drums and on Raman in *Science Today*, 1970. All these sources have been invaluable to me and I wish to record my deep sense of gratitude to the authors of these articles and their publishers. My grateful thanks are also due to Professor S. Chandrasekhar for permission to quote some of his statements.

I am very indebted to Prof. A.K. Ramdas in many ways. He patiently read the manuscript and made illuminating comments and suggestions. He agreed to write a foreword and made available to me much interesting material concerning Raman from his father's writings and collection.

My associate Ralph G. Maines has been extremely helpful in the course of the preparation of the manuscript and I wish to record my thanks to him. I am very indebted to Mrs. Alyne E. Bonnell in our text processing centre, for the enthusiasm and readiness with which she did the typing and the keen interest she took in the work. My wife Kamala has been a constant source of encouragement to me throughout my scientific life. She read the manuscript of this memoir and made interesting comments from the point of view of a non-scientific reader, for which I wish to record my sincere thanks to her.

This work would not have been possible without the support and encouragement of AT&T Bell Laboratories, my employer for the last quarter century.

18th May 1989
AT&T Bell Laboratories
Murray Hill, New Jersey-07974, U.S.A.

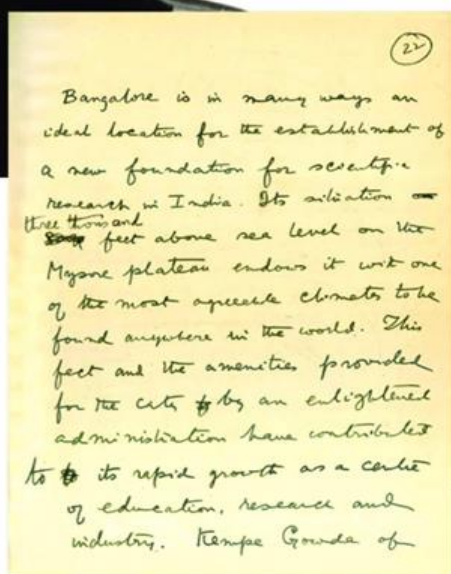
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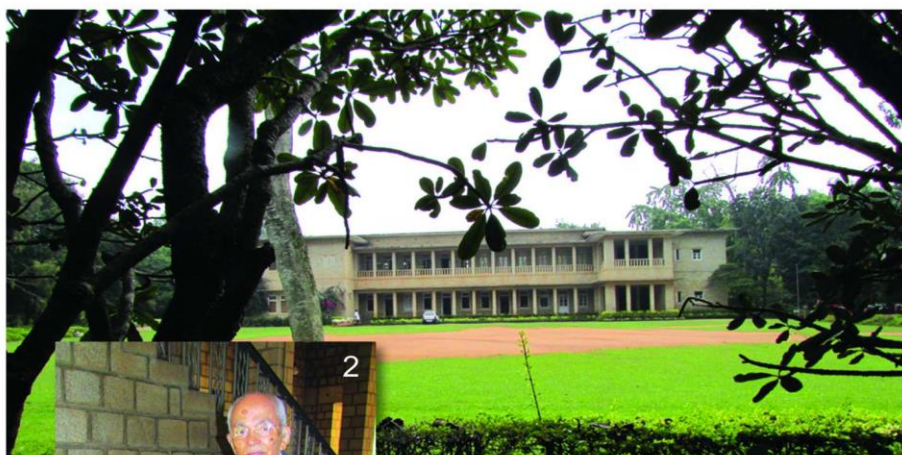
1. C.V. Raman



2



3. A page from Raman's diary.



1. Raman Research Institute main complex.
2. The author visiting the institute in 2016.
3. A display of minerals at the Raman Research Institute Museum.

3



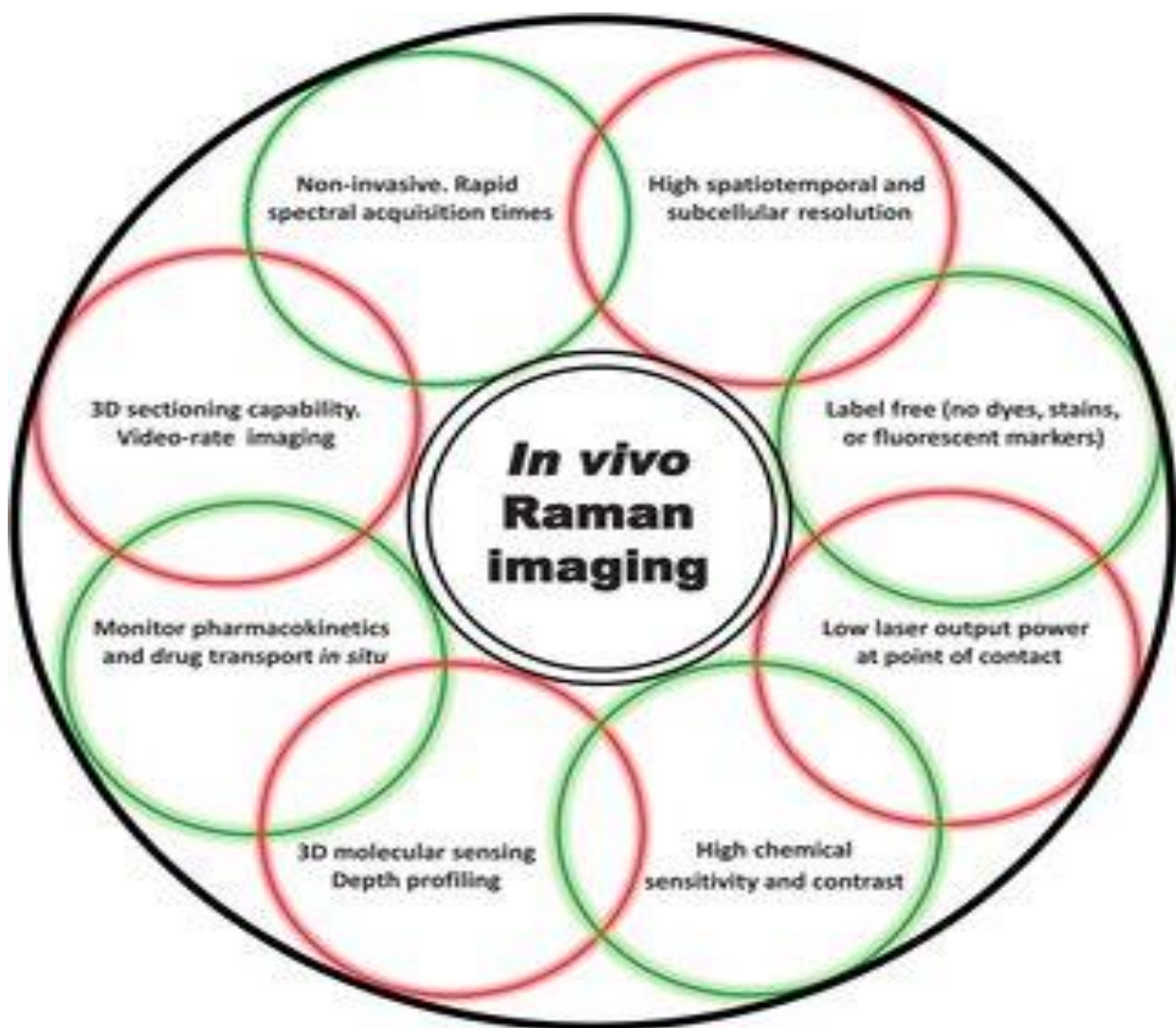
Please visit the web link to read the rest of the Book:
[https://www.ias.ac.in/public/Resources/Other_Publications/e-Publications/003/Chandrasekhara Venkata Raman.pdf](https://www.ias.ac.in/public/Resources/Other_Publications/e-Publications/003/Chandrasekhara_Venkata_Raman.pdf)

Figures / Illustrations

Raman Effect

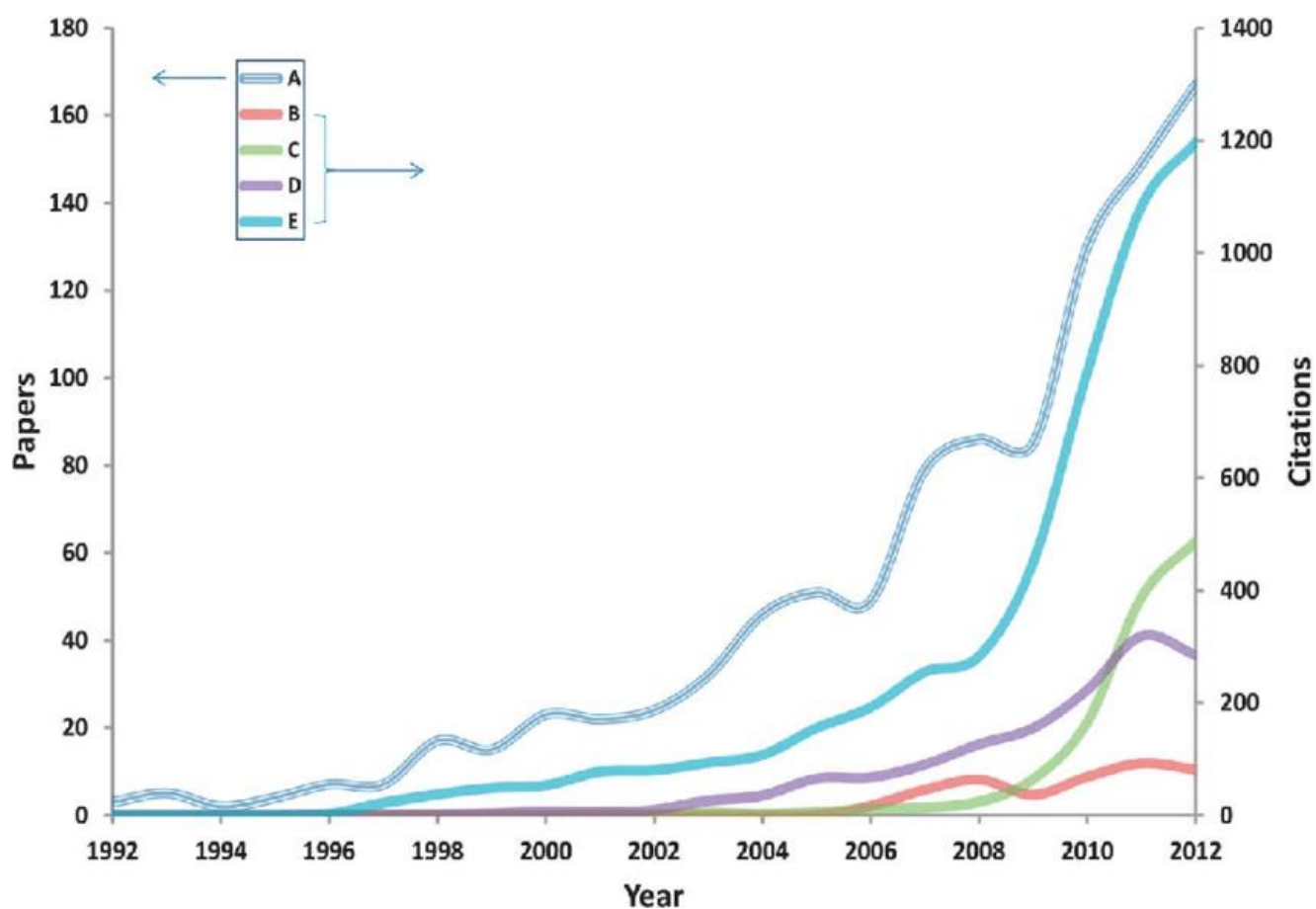
(A) *In vivo*

Raman Imaging



A figurative (as opposed to fibre-optic) bundle of some of the key terms and demonstrated capabilities of in vivo Raman imaging.

(B) Illuminating disease and enlightening biomedicine: Raman spectroscopy as a diagnostic tool



Results of bibliometric analysis of the number of publications (A) and citations (B/C/D/E) per year listed on ISI Thomson Web of Science (<http://wos.mimas.ac.uk/>) for the period 1992-2012, using the search terms (A) Raman AND disease, (B) spatially offset Raman AND disease, (C) SERS AND disease, (D) Raman endoscopy, (E) Raman imaging AND disease.

(c) Timeline of Events/Discoveries

Event/discovery	Year
	
2018 ExoMars Rover, taking Raman spectroscopy to Mars	
2010 Video-rate <i>in vivo</i> SRS Raman imaging by Sunny Xie	
2010 SESORS reported by Graham, Faulds, Stone and Matousek	
2009 Boyle and Smith awarded Nobel Prize in Physics for CCD	
2005 SORS invented by Pavel Matousek	
2000 TERS developed by Volker Deckert	
1997 Single molecule SERS reported by Katrin Kneipp	
1990s Significant increase in commercial instrumentation	
1983 Enhancement of 10^{14} reported by Richard van Duyne	
1982 Use of Ag and Au colloids for SERS by Lee and Meisel	
1980s CCD detectors used for Raman	
1980s Fibre optics coupled with Raman	
1974 Fleischman and colleagues observe surface enhanced Raman scattering (SERS)	
1970s Raman coupled with microscopy	
1969 Invention of charge-coupled device (Willard Boyle and George Smith)	
1964 Townes, Basov and Prochorov awarded Nobel Prize in Physics for invention of the laser	
1960s Stimulated Raman and coherent anti-Stokes Raman (CARS) invented	
1960s Lasers used as light source for Raman spectrometers	
1957-59 Light amplification by stimulated emission of radiation constructed	
1953 First commercial Raman spectrometer	
1950 Observation of resonance Raman (RR) spectra	
1940s Invention of Raman grating spectrometer	
1930s Invention of the monochromator	
1930 Sir Chandrasekhara Venkata Raman awarded Nobel Prize in Physics	
1928 C.V. Raman and K.S. Krishnan: discovery of Raman effect experiments on 28 Feb	
1928 Landsberg and Mandelstam: independent observation of inelastic light scattering	
1927 Compton awarded Nobel Prize in Physics	
1923 Arthur Compton (effect): discovered inelastic X-rays & γ -rays scattering in matter	
1923 Adolf Smekal's prediction of the Raman effect	
1922 CV Raman's monograph published on the Molecular Diffraction of Light	
1921 CV Raman's experiments on the colour of the sea, showing that the colour was due to molecular diffraction	
1917 Albert Einstein first theorizes about stimulated emission (On the Quantum Theory of Radiation)	
1871-1899 Lord Rayleigh (John Strutt) further refines his theory of scattering in a series of papers	
1871 Rayleigh scattering first described	

A timeline of events and discoveries in the history of Raman spectroscopy, Nobel Prizes marked in red (photo of Sir C.V. Raman in the sculpture park of Nehru Science Centre, Mumbai, India, by Prof. Paul O'Brien FRS, School of Chemistry, University of Manchester).

The Life of C.V. Raman

Physicist

Parents : Chandrashekar Ramanathan Iyer,
Parvathi Ammal.



7 November 1888,
Thiruvanaikoil, Trichy, Madras Presidency.



(age 13)

Passed matriculation at age 11 and FA exam
at age 13 from St. Aloysius
Anglo-Indian High School.



1904

Obtained BA degree from
University of Madras.



1907

Married Lokasundari Ammal.



1907

Completed M.Sc degree with highest
distinction at the University of Madras.



Childs: Radhakrishnan and Chandrasekhar.



Published his first academic paper
at age 18.



1917

Was offered the newly endowed
Palit chair of Physics at Calcutta
University and decided to accept it.



1907

Joined the Indian Finance Department and
worked as a Civil Servant
for 10 years in Calcutta.



1932

With his student Suri Bhagavantam
discovered the photons of light carry
angular momentum.



1933

Became professor at the
Indian Institute Science at Bangalore.



Showed that the energy of photons that are
scattered inelastically serves as a 'fingerprint'
for the substance that scatters the light.



1948

Studied the spectroscopic
behaviour of crystals.



1922 - Published his work on Molecular Diffraction of Light".
1926 - Founded the Indian Journal of Physics worked as Editor for that
journal and trained the students.
1928 - Discovery of Raman Effect.
1928 - Wrote article on the theory of musical instruments to the 8th
Volume of the Handbuch der Physik.



21 November, 1970

Died due to major heart attack in the
laboratory of Raman Research Institute.



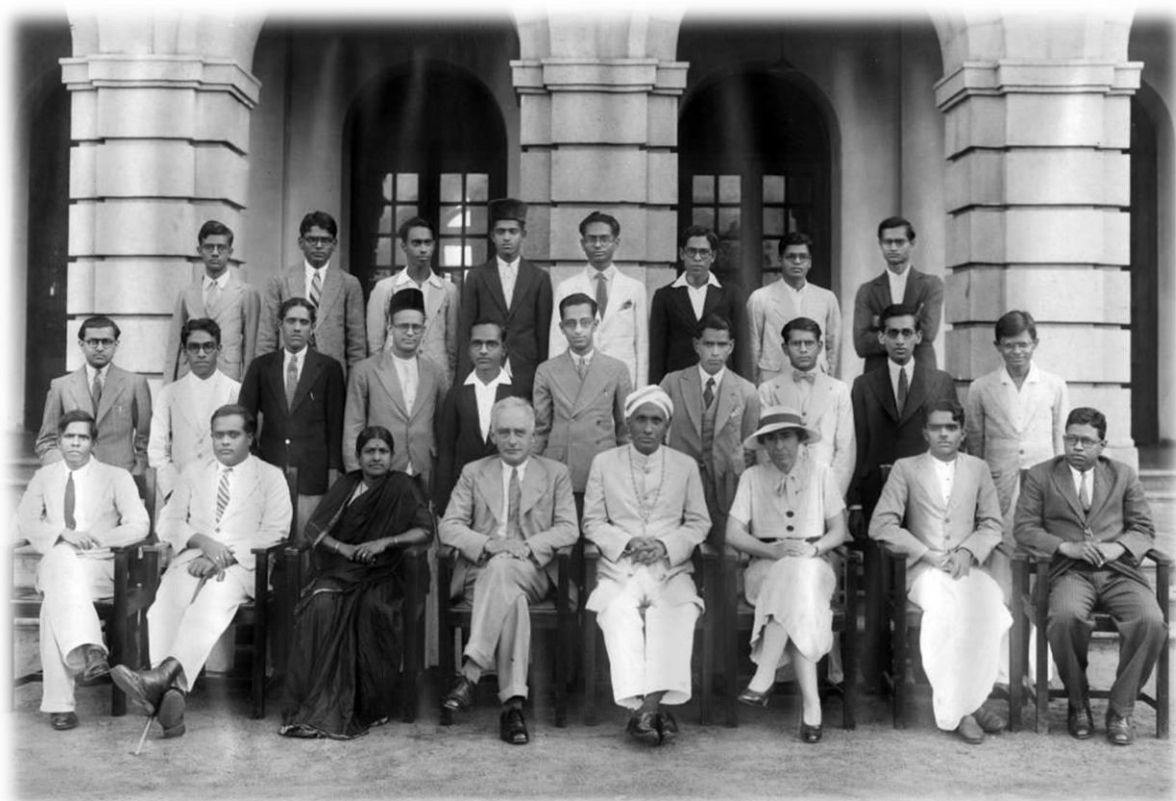
1930 - Nobel Prize in Physics.
1941 - Awarded Franklin Medal.
1954 - Highest civilian award Bharat Ratna.
1957- Lenin Peace Prize.

Max Born @ IISc. Bangalore

*11 December 2019 marks the 137th birth anniversary of Max Born,
who came to IISc on CV Raman's invitation*

<https://connect.iisc.ac.in/2019/12/when-raman-brought-born-to-bangalore/>

[Author: Karthik Ramaswamy : "CONNECT" dated 12 Dec 2019.]



*Max Born (fourth from left) with Lokasundari Ammal (third from left),
CV Raman (fifth from left) and Hedi Born (sixth from left) at IISc.*

*Also seen are Raman's students
(Photo courtesy: RRI Digital Repository)*

The Mysterious Number 137 was the title of a lecture that Max Born delivered to the South Indian Science Association in Bangalore on 7 November 1935. Called the fine structure constant α , 137 is a dimensionless entity (its value is actually its reciprocal), calculated using the charge of an electron, Planck's constant and the speed of light. Since the early 1900s, some physicists have suggested that this number could be at the heart of a Grand Unified Theory because it combines electromagnetism, gravity and quantum mechanics.

The talk was among over 30 lectures that Born gave, both within and outside the Institute, in his capacity as a Reader in Theoretical Physics at IISc, a position he held for six months. The Institute's 1935-36 Annual Report states that his presence provided great stimulus to the work in the Physics Department, which had just been established by IISc's Director CV Raman. The report adds that besides giving lucid lectures, Born continued his own investigations and directed theoretical physics research in the department. But during this period, a political drama, in which Born inadvertently became an actor, was also being played out - one that determined not just his future at IISc but also that of Raman and the direction of research at India's best known science institution.

When Born arrived in IISc on 28 September 1935, with his wife Hedwig (Hedi), he was already a distinguished physicist who was closing in on his 53rd birthday. In the 1920s, along with the likes of Erwin Schrödinger, James Franck, and Werner Heisenberg, he had been instrumental in developing the foundations of quantum mechanics, the theory that describes nature at the scale of atoms and subatomic particles. As a professor at the University of Göttingen, he mentored several physicists, including Enrico Fermi, Robert Oppenheimer and Pascual Jordan - besides his assistant Heisenberg - making the German university one of the most important centres for physics in the world.

But not long after, Born's life - both professional and personal - came to a crossroads. In 1928, he had been nominated by Albert Einstein for the Nobel Prize in Physics (Einstein himself had a strained relationship with quantum mechanics. Annoyed with its probabilistic nature, he famously declared in a letter to Born that "God does not play dice with the universe"). The Nobel Prize Committee, however, did not deem Born's work worthy of the honour, even though Heisenberg received the Prize in 1932 and Schrödinger the following year (Born eventually won the Prize in 1954). But, by the early 1930s, being overlooked for the award was not what was uppermost on his mind.

Adolf Hitler became Chancellor of Germany on 30 January 1933. "Then one evil event followed the other," writes Born in his autobiography *My Life: Recollections of a Nobel Laureate*. On 25 April, he was suspended from his job because of his Jewish heritage. In the coming months, he was also to lose his doctorate,

professorship, property, and citizenship. When he was suspended, Born's first thought was about the effect it would have on the research at Göttingen. "All I had built up in Göttingen, during twelve years' hard work, was shattered. It seemed to me like the end of the world," he writes. His next thought was the safety of his family. "I went for a walk in the woods, brooding on how to save my family," he adds. He realised that they - Max, Hedi, and their daughters Irene and Gritli - had to leave their homeland. In early May, they fled Germany by train and made their way to northern Italy.

The family then moved to Cambridge, UK, where Born had been offered a temporary lecturership position. During his time there, he received a letter from India. It was from Raman. The Indian physicist had, with the help of KS Krishnan, discovered what came to be known as the Raman Effect. The discovery, for which Raman was knighted in 1929 and won the Nobel Prize in 1930, provided further evidence for the quantum nature of light.

In the letter, Raman asked Born if he could recommend names of "young and efficient" theoretical physicists who might be interested in working in IISc. The latter responded by saying that even if he did, he could not persuade any of them to go to Bangalore without knowing much about the place. Then Raman wrote back asking Born if he himself could come to IISc for six months to "have a look at the place." Born was inclined to make the move since his Cambridge appointment was going to end soon. He consulted with Hedi, who readily agreed to join him. At Cambridge, she had no friends, felt cut off from her roots, and was overworked, according to Born. Once Born said yes, it did not take Raman long to convince the Governing Council of IISc to create a temporary position of Reader in Theoretical Physics. For his services, Born would receive an honorarium of Rs 15,000 for a period of six months, more than what he was getting paid at Cambridge.

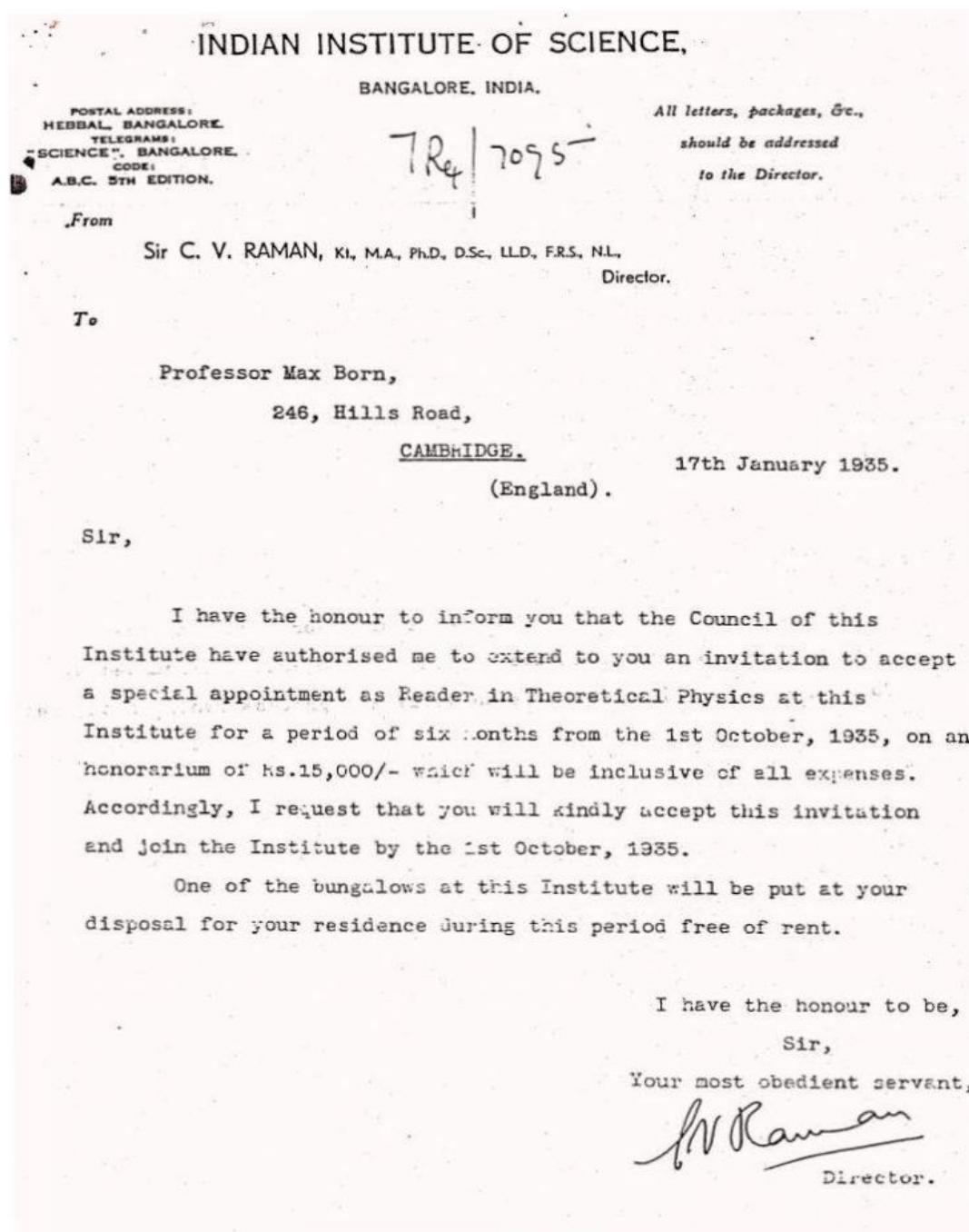
The Borns arranged for their children to be sent to live with families of friends and set off for India on the steamer Staffordshire. They arrived in Cochin (now Kochi), where they spent a day, and travelled to Bangalore from there. At IISc, they were received by Raman's wife Lokasundari Ammal, who took them to a two-storey bungalow, which was to be their home for the next few months. "We had a large garden with beautiful trees and flowers," writes Born, "and two tennis courts which were screened off by marvellous bougainvillea shrubs. The Raman family lived in a similar house just across the road."

The Borns did not get to meet Raman for the first few days. And when they did, they were fascinated by his appearance and talk. To Hedi, Raman in his Indian dress and turban looked like a prince from the Arabian Nights.

During their stay, the Borns played tennis and socialised, mostly with Indians. They also travelled to Bombay, Agra, Nilgiris, and Mysore for the annual Dasara

festivities. Hedi, in particular, seemed to be enjoying herself in India, in stark contrast to her time in Cambridge. This in spite of two major illnesses, including a nasty sunstroke which kept her in bed in a dark room for weeks together.

Born had mixed feelings about India. Though the stay was pleasant, he was disconcerted by certain aspects of life here: the poverty, the gulf that divided Indians and the British, the opulence of the Maharajas, and the caste system.



Letter of appointment as Reader in Theoretical Physics from CV Raman to Max Born
(Image Courtesy: IISc Archives)

In Bangalore, Born also got to meet Mysore's Dewan Mirza Ismail, whom he came to admire. "He was a Mohemmedan while the majority of the inhabitants of Mysore were Hindu. But this seemed to cause no friction," he writes. When Ismail asked Born whether he knew any good architects to work for Mysore State, Born suggested the name of his nephew Otto Koenigsberger, who had also fled Germany. Koenigsberger eventually became the State Architect of Mysore, designing and building several prominent buildings in Bangalore, including in IISc.

On the academic front, Born spent a considerable amount of his time preparing for and giving lectures. Even though he and Raman often had "violent" discussions on modern theoretical physics, they got along well. Raman was keen to create a permanent chair for the German in the Institute. When he asked Born about whether he would be willing to stay on in Bangalore, Born - and Hedi - were open to the idea. Two search committees were set up, one in Bangalore (led by Raman), and the other in London (led by the physicist Ernest Rutherford). This seemed a mere formality - both committees were in favour of offering the position to Born.

However, Raman also had to seek the approval of the Senate - the faculty body - and the Council. With some persuasion and questionable tactics, he was able to convince them to create a Professorship in Mathematical Physics at IISc (Born writes that Raman later informed him that he intentionally sent invites to his "enemies" on the Council late so that they would not show up).

It was during the Senate meeting that Born first got a whiff of the ugly spat between Raman and IISc's establishment. At the meeting, Kenneth Aston, an Englishman recently hired as a professor in the Electrical Technology Department, attacked not just Raman but also Born. "The English Professor Aston went up and spoke in a most unpleasant way against Raman's motion, declaring that a second-rank foreigner driven out from his own country was not good enough for them. This was particularly disappointing since we had been kind to the Astons, as I mentioned before [they stayed as guests with the Borns when they arrived until their bungalow was ready]. I was so shaken that when I returned to Hedi, I simply cried," Born writes.

In 1933, when Raman became Director of IISc 24 years after it was founded, it still had only four departments: General Chemistry, Organic Chemistry, Biochemistry and Electrical Technology. And research was skewed heavily towards industrial applications. Among his main tasks as Director was to establish a physics department, a recommendation that had been made by two government-appointed review committees, the Pope Committee in 1921 and the Sewell Committee in 1931.

Once the department was set up, Raman - its only faculty member - initiated investigations in key areas of theoretical and experimental physics with his

students, leading to several publications of high quality in a short period of time. But Raman realised that in order for him to make Bangalore a world-class centre for physics, it would need world-class physicists. He was particularly keen that IISc become a hub for atomic physics.

Raman's tenure as Director coincided with the rise of the Nazis in Germany. Several physicists of Jewish heritage were being forced out of their country. Raman believed that he might be able to convince some of them to come to IISc. "[After setting up new lines of research], he then identified gaps in knowledge in India and adopted a strategy of trying to recruit to the Institute faculty from among the reputed scientists who were fleeing from the tyranny of Hitler," says S Ramaseshan, Raman's nephew and former Director of IISc, in a profile of his uncle in *Current Science*.

It was then that Raman invited Born to IISc. Later he also wrote to a few other Jewish scientists, including Schrödinger, who, according to Ramaseshan, wrote back saying that Raman's offer arrived a bit too late as he had just accepted an offer from the School for Theoretical Physics in Dublin, Ireland. He adds that Schrödinger also expressed his regret that he could not settle in the land of the Upanishads.

Raman's effort to bring international scientists to IISc was part of an ambitious project to make IISc be counted among the best in Asia, if not the world. "In walks a spirited giant who finds this set-up all wrong. His mind is full of visions of Cambridge and Caltech, and he wants to recreate their atmosphere in his backyard," writes G Venkataraman, a condensed matter physicist and science historian, in his book *Journey into Light: Life and Science of CV Raman*. But it did not take long for Raman's grand plans to be thwarted.

Opposition to Raman began with his attempt to speed things up at the "sleepy place where little work was done by a number of well-paid people," as Born describes IISc. Raman's enthusiasm to change the work culture at IISc was perceived as criticism of the establishment. But there were other reasons for the growing animosity between him and some faculty members as well as the Council.

Raman wanted the work in physical chemistry (he called it chemical physics), then being undertaken in the General Chemistry Department, to be conducted under his watchful eyes in the new Physics Department. The move upset HE Watson, a professor in the General Chemistry Department, who resigned in protest. Born suspected that there was more to this resignation than his resentment of an administrative decision. "Watson's friends and he himself may have expected that he was to be the new Director after Sir Martin [Forster] retired. Certainly Watson did not like to continue under an Indian Director. I was told this by some

of Watson's English friends," recounts Born in a letter to Rutherford written after he left Bangalore and returned to the UK.

In the early 1930s, IISc's finances were not in great shape - the Mysore State had reduced its annual contribution from Rs 50,000 to Rs 30,000. But Raman, given his ambitious goals for the Physics Department, wanted more money, more than the capital grant of Rs 1 lakh (and the recurring sum of Rs 25,000) allocated by the Institute. "He therefore re-apportioned the budget to aid the fledgling Physics Department, an act which invited charges of embezzlement!" Venkataraman writes.

The situation was precipitated by Raman's apparent lack of administrative tact - a flaw in his character that even his most ardent cheerleaders find hard to defend. "Raman's ebullience and sharp tongue, his pride and prejudice, not infrequently surfaced to such levels that open mindedness and the future of the Institute had to take a backseat," Subbarayappa concedes in his book *In Pursuit of Excellence: A History of the Indian Institute of Science*. "Raman went in there like a bull in a China shop," writes Ramaseshan.

It was under these circumstances that Raman was working towards creating a permanent professorship for Born, a move that was not popular among some faculty members. The Born episode brought things to a boil, notes Venkataraman, leading to games of one-upmanship between Raman and the Council.

In the letter to Rutherford, Born writes that he did not see the unprecedented verbal attack on Raman and him at the Senate meeting as an isolated incident. He was convinced that the Council appointed Kenneth Aston as a professor to stir trouble and weaken Raman.

Amidst rising tensions, the Government in January 1936 appointed another review committee, headed by James Irvine, Principal and Vice Chancellor of the University of St Andrews, UK. Its mandate was to look into the working of the Institute and to make recommendations on how it could fulfil the purpose for which it was set up, while taking into account its financial resources.

Some historians have suggested that the real reason the committee was instituted was to clip Raman's wings and undo his controversial decisions. Born concurred. He writes that Raman's enemies in the Council had made up their mind to get rid of him. "It was evident to me from the beginning that they had received instructions beforehand."

The Irvine Report was submitted in late March that year. Among its many suggestions included the appointment of a Registrar, thus creating a parallel power structure in IISc. It also blamed Raman for the faulty use of Institute funds. While appreciating the work done in physics, the report expressed concern

that the "centre of gravity" had shifted from chemistry to pure physics. It believed that modern mathematical physics "has little contact with industry, and in this respect cannot compete with Chemistry as a subject likely to be of service to India."

On the issue of Max Born, the report said that though "the presence of an eminent mathematician such as Dr Born would have a stimulating effect on the activities of the Department of Physics," the recently-approved position of Professor of Mathematical Physics should be abolished. The Committee justified the suggestion on the basis of the prevailing fiscal condition of the Institute.

The recommendations of the report were discussed at length at an extraordinary meeting of the Council in June 1936. At the meeting, a memorandum was also circulated by Raman critiquing many of its suggestions. But a majority of the members present were in favour of accepting them.

"Meanwhile, the opposition to Raman had been gathering momentum," Subbrayappa writes. He was becoming increasingly isolated. Born, who left India at the end of his six-month appointment, pleaded with Rutherford to intervene and "save Raman from a precipitous fall," Subbarayappa adds. However, Rutherford's attempted intervention had little impact on the Council. Eventually on 19 July the following year, Raman was forced to resign as Director but continued as a professor and the Head of the Physics Department until he retired in 1948.

Born and Raman remained friends for a few years after the former left IISc. Raman even invited Born to become an Honorary Fellow of the Indian Academy of Sciences, which he founded. But their relationship soured in later years, thanks to an intellectual dispute that had its origins in Born's lectures in Bangalore. In IISc, Born devoted a few of his talks to the theory of lattice dynamics - the theory of how atoms in crystalline solids stick to each other and vibrate. But Raman felt that the theory did not explain the experimental observations he had made in his lab.

During the ensuing debate, which went on for many years, most theoretical physicists threw their weight behind Born, who had become the Tait Professor of Natural Philosophy at the University of Edinburgh in the UK. In 1947, Born's student Helen Smith's experiments also supported his ideas (though research in the 1950s and early 1960s showed that Raman was partly right). Raman seemed to take it personally.

The Borns met the Ramans twice after they left India. The first was at Bordeaux in France for the 25th anniversary of the discovery of the Raman Effect. At the reception, they greeted each other cordially, according to Born. But for the rest

of the congress, Raman "was nervous, excitable and aggressive." The second time they met was at one of the Lindau meetings of Nobel Laureates in Germany. Again, Raman greeted them cordially, but the next day his attitude changed, writes Born. "He must have suddenly remembered that I was his 'enemy'."

Born and Hedi were especially disappointed that the controversy affected their relationship with Lokasundari. "Hedi and I regret all this and particularly the split between us and Lady Raman, whom we loved dearly," he laments.

Nonetheless, Born was an admirer of Raman's devotion to research and the risks he was willing to take for Indian science. "It makes me sad to think that by inviting me to India and trying to keep me there permanently he has brought himself into a precarious situation, and had to give up this leading position at the [Indian] Institute of Science."

"CONNECT"

An initiative of the Office of Communications
Indian Institute of Science
Bangalore



भारतीय विज्ञान संस्थान

The Mysterious 137



From physics, mathematics and science, to mysticism, occultism, the Kabbalah and the Torah, the number 137 may just be the most magical and important number in the universe.

- The fine structure constant, a number that emerges from theories of quantum mechanics, is measured in laboratory experiments to be roughly $1/137$.
- This slightly coincidental number is a perennial source of excitement.
- While its meaning holds some intrigue, the greatest mystery surrounding this number is why it so fascinates physicists.

In Physics

- Since the early 1900s, physicists have postulated that the number could lie at the heart of a grand unified theory, relating theories of electromagnetism, quantum mechanics and, especially, gravity.
- $1/137$ was once believed to be the exact value of the fine-structure constant. The fine-structure constant, a dimensionless physical constant, is approximately $1/137$, and the astronomer Arthur Eddington conjectured in 1929 that its reciprocal was in fact precisely the integer 137, which he

claimed could be "obtained by pure deduction". This conjecture was not widely adopted, and by the 1940s, the experimental values for the constant were clearly inconsistent with the conjecture, being roughly $1/137.036$.

- Physicist Leon M. Lederman numbered his home near Fermilab 137 based on the significance of the number to those in his profession. Lederman expounded on the significance of the number in his book *The God Particle: If the Universe Is the Answer, What Is the Question?*, noting that not only was it the inverse of the fine-structure constant, but was also related to the probability that an electron will emit or absorb a photon—i.e., Feynman's conjecture. He added that it also "contains the crux of electromagnetism (the electron), relativity (the velocity of light), and quantum theory (Planck's constant). It would be less unsettling if the relationship between all these important concepts turned out to be one or three or maybe a multiple of pi. But 137?" The number 137, according to Lederman, "shows up naked all over the place", meaning that scientists on any planet in the universe using whatever units they have for charge or speed, and whatever their version of Planck's constant may be, will all come up with 137, because it is a pure number. Lederman recalled that Richard Feynman had even suggested that all physicists put a sign in their offices with the number 137 to remind them of just how much they do not know.

In Mathematics

137 is:

- the 33rd prime number; the next is 139, with which it comprises a twin prime, and thus 137 is a Chen prime.
- an Eisenstein prime with no imaginary part and a real part of the form $3n - 1$
- the fourth Stern prime.
- a Pythagorean prime: a prime number of the form $4n + 1$, where $n = 34$ ($137 = 4 \times 34 + 1$) or the sum of two squares $11^2 + 4^2$ ($121 + 16$).
- a strong prime in the sense that it is more than the arithmetic mean of its two neighbouring primes.
- a strictly non-palindromic number and a primeval number.
- a factor of 10001 (the other being 73) and the repdigit 11111111 ($= 10001 \times 1111$).
- using two radii to divide a circle according to the golden ratio yields sectors of approximately 137° (the golden angle) and 222° .
- $1/137 = 0.007299270072992700\dots$, so its period value is palindromic and has a period length of only 8.

The Most Important Number? It's 137. This Is Why

Dr Katie Spalding

Freelance Writer

Katie has a PhD in maths, specializing in the intersection of dynamical systems and number theory.

The fine structure constant is a mysterious little guy – tiny, dimensionless, seemingly random, and yet it holds the key to life itself.

As the mathematician De La Soul famously stated, three is the magic number. But if physicist Richard Feynman is to be believed, that figure is off by a factor of about 400. For Feynman, you see, the "magic number" is around $1/137$ – specifically, it's $1/137.03599913$.

Physicists know it as α , or the fine structure constant. "It has been a mystery ever since it was discovered," Feynman wrote in his 1985 book *QED: The Strange Theory of Light and Matter*. "All good theoretical physicists put this number up on their wall and worry about it."

It's both incredibly mysterious and unbelievably important: a seemingly random, dimensionless number, which nevertheless holds the secret to life itself.

"It's a measure of the strength of the interaction between charged particles and the electromagnetic force," explained SUNY Stony Brook astrophysics professor Paul M Sutter in an article for Space.

"If it had any other value, life as we know it would be impossible," he wrote. "And yet we have no idea where it comes from."

Normally, this would be the part where we give you some examples of where the value turns up – but the answer to that, quite literally, is "everywhere." It was first discovered in 1916, by the physicist Arnold Sommerfeld, but it had already been turning up in equations for decades before that. It lurks in formulas describing light and matter, and it governs everything from the smallest hydrogen atom to the formation of stars.

"In our everyday world, everything is either gravity or electromagnetism," Holger Müller, a physicist at the University of California, Berkeley, told Quanta Magazine. "And that's why α is so important."

Of course, physics is no stranger to constants - there's c , the speed of light; G , the gravitational constant; in quantum physics there's both h and $\hbar$ to describe the Planck constant; if you're a real aficionado you may even know about k , the Boltzmann constant. But α has something none of those other constants have - or, to be more precise, it *doesn't* have something they *do*.

"There are no dimensions or unit system that the value of the [fine structure constant] depends on," wrote Sutter. "The other constants in physics aren't like this."

Take the speed of light, for example. Look it up in a search engine, and you'll find it's equal to 299,792,458 meters per second. Or is it 670,615,200 miles per hour? Our mistake: it's actually 1,802,600,000,000 furlongs per fortnight. Screw it - let's just say it's one light-year per year.

Get the picture yet? The value of the constant isn't actually, well, constant - it depends on the units you use. But the fine structure constant doesn't have that property: it's an entirely dimensionless constant.

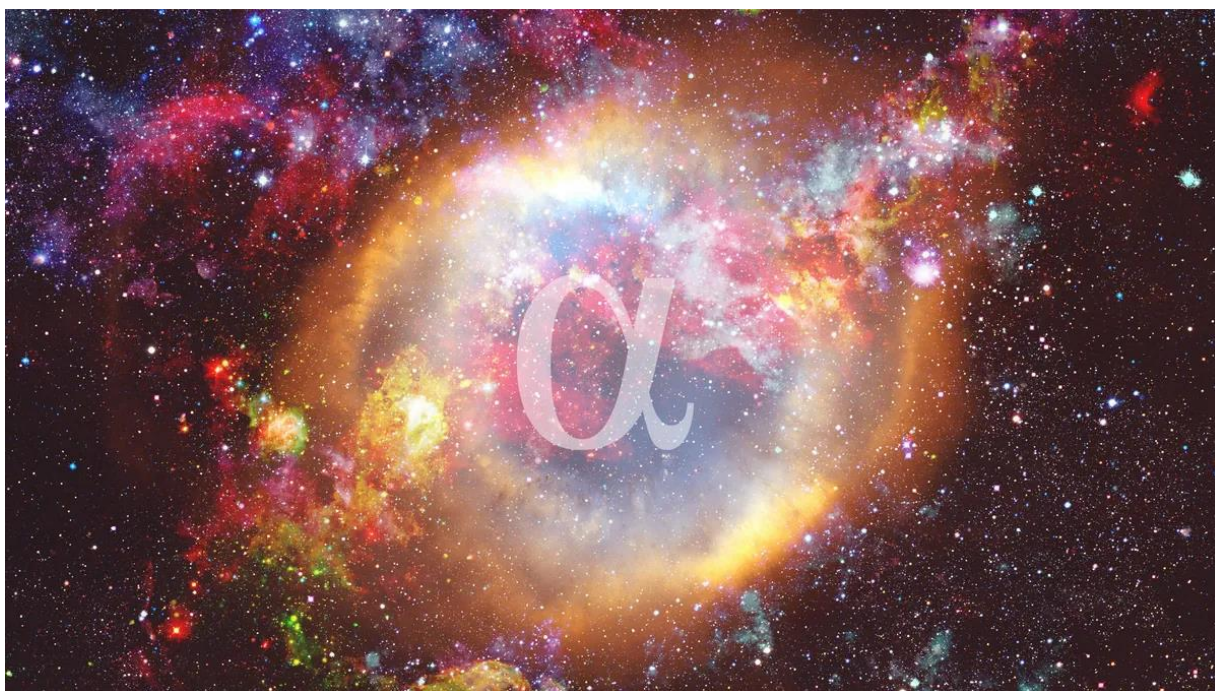
"If you were to meet an alien from a distant star system, you'd have a pretty hard time communicating the value of the speed of light. Once you nailed down how we express our numbers, you would then have to define things like meters and seconds," explained Sutter.

"But the fine structure constant? You could just spit it out, and they would understand it."

But perhaps the weirdest thing about this seemingly most pure of constants is that it may, in fact, not be constant. Some physicists have suggested that today's α is actually slightly larger than it used to be - only by one part in about 100,000 over six billion years, but that's enough to have some pretty huge ramifications in the long run. Change that 137 to 138, for example, and you decrease the value of α by 0.00005 - enough, some scientists argue, to prevent stars from creating carbon, thus halting the creation of life as we know it.

As Feynman put it: "It's one of the greatest damn mysteries of physics: a magic number that comes to us with no understanding by man.

"You might say the 'hand of God' wrote that number, and 'we don't know how He pushed his pencil.'"



α - the fine structure constant - holds the secret to life.

Image credit: NASA Images/Shutterstock.com, IFLScience

Please visit these web links to know more:

01] <http://www.feynman.com/science/the-mysterious-137/>

02] <https://awarenessact.com/the-number-137-one-of-the-biggest-mysteries-of-the-unknown/>

03] <https://science.howstuffworks.com/dictionary/physics-terms/why-is-137-most-magical-number.htm>

04] [https://en.wikipedia.org/wiki/137_\(number\)](https://en.wikipedia.org/wiki/137_(number))

05] <https://bigthink.com/hard-science/number-137-physics/>

06] <https://www.iflscience.com/the-most-important-number-its-137-this-is-why-64100>

07] <https://www.nature.com/articles/138332a0>

The Quantum Indians

https://www.youtube.com/watch?v=7z9NUV_YrOo&ab_channel=IndianDiplomacy

A Documentary Film

This documentary won the prestigious **National Film Award** for the best educational film in 2013 in India. President Shri Pranab Mukharjee gave away this award in a glittering ceremony on 3rd May 2014. It is an award for an extremely efficient and precise analysis of the contributions of three renowned scientists in a manner that not only educates today's generation but also provides insights into complex scientific phenomena in an accessible manner. At the turn of the 20th century, the world was witnessing a renaissance in the area of quantum physics through the work of great scientists such as Max Planck, Albert Einstein, Ernest Rutherford or Niels Bohr. **Unknown to the world, three Indian scientists were also making significant contributions to the quantum world with revolutionary deductions, interpretations and theories.**

Dr. Satyendra Nath Bose devised a statistical theory of counting photons - a revelation even to Albert Einstein -- that paved the way for the two great minds to work in tandem in formulating fundamental theories as the Bose-Einstein Statistics and Bose-Einstein Condensate. Boson, the class of particles that obey Bose-Einstein statistics, was named after Dr. S. N. Bose. **Sir C. V. Raman** gave the world what is known as the Raman effect, which redefined how we see light and colour. Another contemporary, **Dr. Meghnad Saha** produced an equation that explained stellar radiation and is regarded as one of the fathers of modern astrophysics. All the three scientists started

their careers at the Calcutta University, became Fellows of the Royal Society, and Raman was the first and only Indian to be awarded the Nobel Prize for physics.

The film is a tribute to the three exemplary minds, the significance of whose contributions was of vital importance during that time, and even today with great strides being made in quantum physics, fibre optics, nuclear science or astrophysics. They were not only great scientists, but were rooted to the social and political realities of the time and dedicated their lives to modern science in India. Along with being institutions by themselves, they built stellar institutions in the country that inspired many great scientists of the following generations.



Dr SN Bose



Dr Meghnad Saha



Dr CV Raman

Raman Research Institute

[CV Raman Avenue, Sadashivanagar, Bengaluru - 560 080]

<https://www.rri.res.in/>

The Raman Research Institute is an autonomous research institute engaged in research in basic sciences. The institute was founded in 1948 by the Indian physicist and Nobel Laureate Sir C V Raman. Sir C V Raman served as its director carrying on his personal research until his demise in 1970. It was restructured in 1972 to become an aided autonomous institute receiving funds from the Department of Science and Technology of the Government of India.

History

In December 1934, the Government of Mysore gifted a plot of land in Bangalore to Professor Raman for the creation of a research institute. In the same year, the Indian Academy of Sciences was founded by Prof. Raman. Some years following the creation of the Raman Research Institute in 1948, Prof. Raman made a gift of various movable and immovable properties to the Academy for the use and benefit of the Raman Research Institute. After the Professor's demise in November 1970, the Academy created a public charitable trust: the Raman Research Institute Trust. The lands, buildings, deposits, securities, bank deposits, money, laboratories, instruments, and all other movable and immovable properties held by the Academy for the Raman Research Institute were transferred to the RRI Trust. The foremost function of the RRI Trust was to maintain, conduct and sustain the Raman Research Institute.



Research Areas

Today, the main areas of research at the Institute are Astronomy & Astrophysics, Light & Matter Physics, Soft Condensed Matter, and Theoretical Physics.

Astronomy & Astrophysics

From the beginning humankind has looked up at the sky with a sense of curiosity. It is no wonder that astronomy is one of the oldest of natural sciences. The field of Astronomy and Astrophysics pertains to a detailed study of the physical, chemical and dynamic properties of celestial objects. The research conducted in the AA group at RRI can be broadly classified into four areas:

(a) Theoretical Astrophysics that involves development of analytical models and numerical simulations describing the dynamics, physical properties and underlying physical phenomena in celestial objects like stars, planets, galaxies, interstellar medium etc. Theorists also work on answering fundamental questions on the formation and evolution of the Universe, a branch of astrophysics called cosmology.

(b) Observational Astronomy on the other hand uses telescopes built across the globe to study radiation from space across the entire electromagnetic spectrum – low frequency (long wavelength) radio waves to very high frequency (short wavelength and highly energetic) gamma rays. These observations test existing theoretical models and also give rise to new questions that call for answers.

(c) Experimental Astronomy involves the design, construction and operation of telescopes for very specific purposes to address key unsolved problems, and are strategically located around the world and in space.



(d) Algorithms & Signal processing where a variety of methods and modelling are employed to amplify and or isolate the required astronomy signal from other foregrounds, backgrounds and unwanted interference and confusion.

Light & Matter Physics

Members of the Light and Matter Physics (LAMP) group at RRI are pursuing research in an area of light-matter interaction which is a combination of Atomic, Molecular and Optical (AMO) physics on one hand, and intense laser produced plasmas on the other. Light-matter interactions are being investigated by this group in both classical and quantum domains using experiments as well as numerical and theoretical analysis. The interactions are studied at very high plasma temperatures, room temperature, and at extremely low temperatures attained through laser cooling methods. The use of light from the highest energy densities to the single photon regime allows an impressive range of energy scales to be investigated.

The research of the LAMP group stresses on demonstration of quantum logic using ultra-cold atoms loaded in optical lattices and various nano-traps, investigation of transport and localization properties of light in various random media, ultrafast laser induced plasmas from solid targets, nonlinear optical properties of nanomaterials, laser cooling and trapping of atoms, molecular spectroscopy, cold collisions, investigations on spin statistics, ion trapping, atoms in cavities, response of cooled atoms to external fields, quantum optics with neutral atoms and non-classical light sources, quantum walk of light, manufacture of single photon sources based on spontaneous parametric down-conversion and their applications to fundamental tests of quantum mechanics, quantum information and computing and quantum communication, etc. Currently, quantum logical gates are being designed by tailoring the internal degrees of freedom of quantum optical tools in external potentials.

Soft Condensed Matter

The SCM group at RRI started as a Liquid Crystal laboratory and is well known for the discovery of several new types of Liquid Crystals. This includes the discotic phase made up of disc-like molecules, biaxial Smectic-A phase and a new type of Twist Grain Boundary phase. Since then, the group has diversified to include research on a wider range of soft materials including biological systems.

Soft Condensed Matter (SCM) includes the investigation of materials like emulsions, colloidal suspensions, liquid crystals, polymer gels or solutions, macro-molecular assemblies, and biological materials like lipid membranes, cells, tissue, etc. Such materials are made up of macromolecules or supramolecular entities that are held together by very weak interactions, of the order of thermal energy. These materials exhibit very rich phase behaviour, forming a plethora of structures over a wide range



of length scales, each with unique and fascinating physical properties. Moreover, these materials can exhibit both solid-like and fluid-like properties and are generally termed as viscoelastic. The material properties can be easily tuned by changing various physical parameters such as temperature, surface properties, chiral effects or by external electrical or mechanical stimuli. Besides being of fundamental interest to the study of phase transitions and cooperativity arising out of many-body interactions, these materials also find a wide range of applications owing to the easy tunability of their properties. In recent times the field has diversified to include driven granular systems, active materials made up of self-propelled particles, reconstituted cellular systems, etc. The field of soft materials is also a testing ground for theories and models of equilibrium and non-equilibrium statistical physics.

Biophysical systems present a new class problem which are of interest not only from a biology context but also from a physics perspective. For example, the cytoplasm of a eukaryotic cell is filled with an active biopolymer matrix. Unlike synthetic polymer gels, the filaments that constitute this matrix are held out of equilibrium and undergo constant polymerisation-depolymerisation process, and special proteins called molecular motors can generate active stresses causing macroscopic flows. These active processes drive cellular dynamics like locomotion, division, shape change, etc. The cell nucleus is also filled with a polymer matrix—the DNA and its associated proteins. Here DNA conformations and control of gene expression are dictated by polymer physics driven by active dynamics and DNA-protein interactions. These problems are tackled using theoretical understanding of non-equilibrium dynamics as well as experimental strategies.

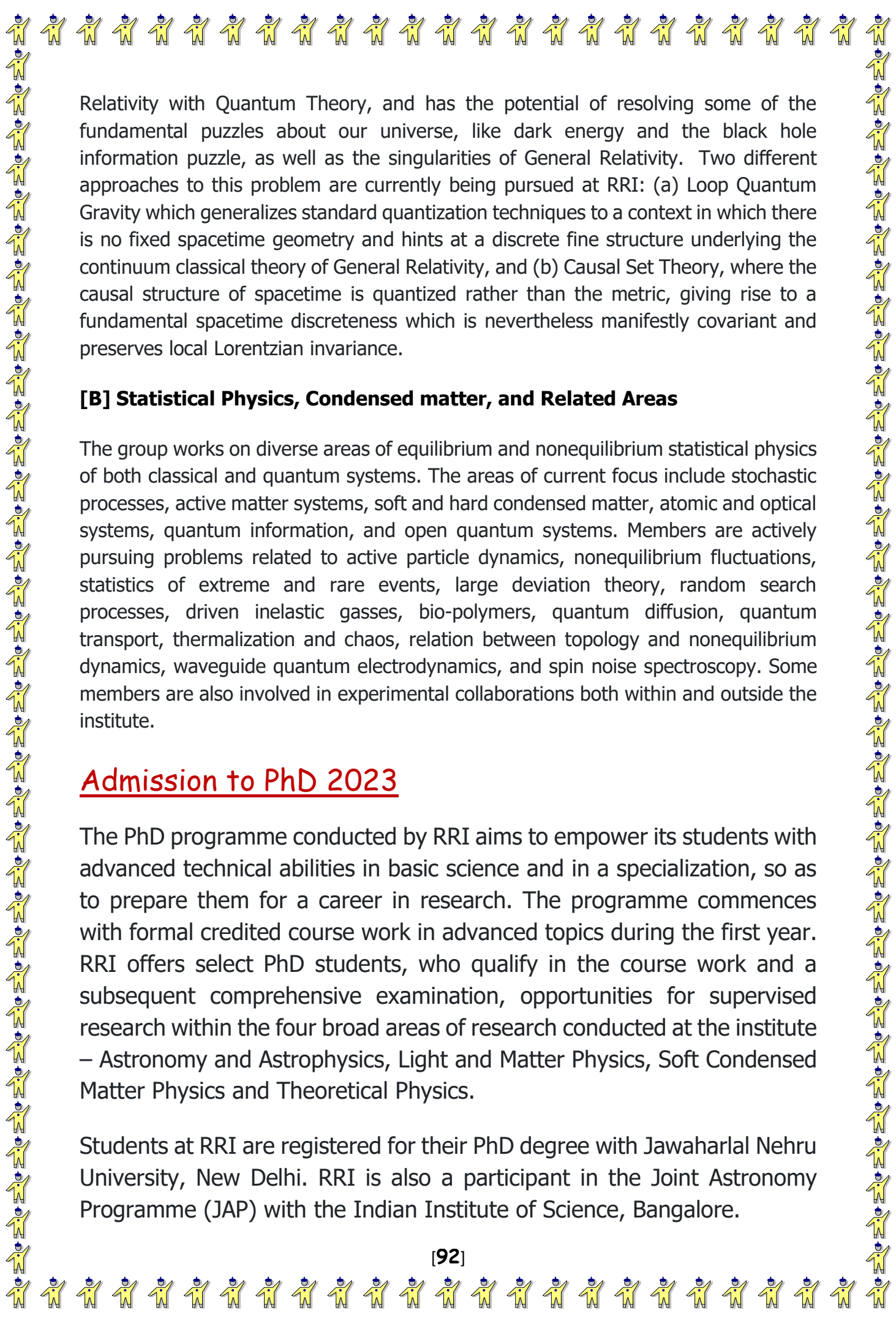
Current research areas of the SCM group at RRI includes the study of topological structures and phase behaviour of liquid crystals, non-equilibrium flows and pattern formation in suspensions, jamming in colloidal suspensions, mechanical properties of living cells, and physics of DNA-protein interactions. The department has state of the art experimental facilities like confocal fluorescence microscope, scanning electron microscope, small angle x-ray scattering setups, Raman microscope, atomic force microscope, etc, apart from several techniques developed in-house.

Theoretical Physics

Theoretical physics is a branch of physics that uses mathematical tools to try to understand the inner workings of nature. The current focus areas of the theoretical physics group are:

[A] Classical and Quantum Gravity

The group works on problems ranging from classical to quantum gravity, with a current focus on the latter. A quantum theory of gravity must merge General



Relativity with Quantum Theory, and has the potential of resolving some of the fundamental puzzles about our universe, like dark energy and the black hole information puzzle, as well as the singularities of General Relativity. Two different approaches to this problem are currently being pursued at RRI: (a) Loop Quantum Gravity which generalizes standard quantization techniques to a context in which there is no fixed spacetime geometry and hints at a discrete fine structure underlying the continuum classical theory of General Relativity, and (b) Causal Set Theory, where the causal structure of spacetime is quantized rather than the metric, giving rise to a fundamental spacetime discreteness which is nevertheless manifestly covariant and preserves local Lorentzian invariance.

[B] Statistical Physics, Condensed matter, and Related Areas

The group works on diverse areas of equilibrium and nonequilibrium statistical physics of both classical and quantum systems. The areas of current focus include stochastic processes, active matter systems, soft and hard condensed matter, atomic and optical systems, quantum information, and open quantum systems. Members are actively pursuing problems related to active particle dynamics, nonequilibrium fluctuations, statistics of extreme and rare events, large deviation theory, random search processes, driven inelastic gasses, bio-polymers, quantum diffusion, quantum transport, thermalization and chaos, relation between topology and nonequilibrium dynamics, waveguide quantum electrodynamics, and spin noise spectroscopy. Some members are also involved in experimental collaborations both within and outside the institute.

Admission to PhD 2023

The PhD programme conducted by RRI aims to empower its students with advanced technical abilities in basic science and in a specialization, so as to prepare them for a career in research. The programme commences with formal credited course work in advanced topics during the first year. RRI offers select PhD students, who qualify in the course work and a subsequent comprehensive examination, opportunities for supervised research within the four broad areas of research conducted at the institute – Astronomy and Astrophysics, Light and Matter Physics, Soft Condensed Matter Physics and Theoretical Physics.

Students at RRI are registered for their PhD degree with Jawaharlal Nehru University, New Delhi. RRI is also a participant in the Joint Astronomy Programme (JAP) with the Indian Institute of Science, Bangalore.

School/College visits

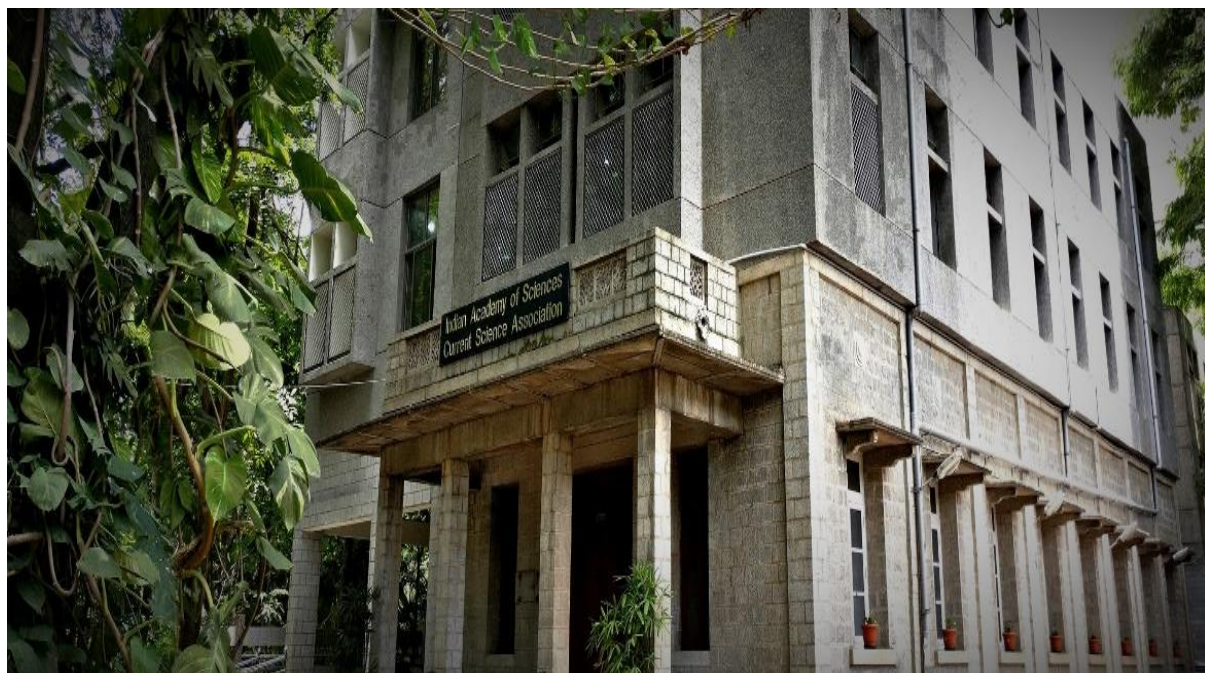
The Raman Research Institute (RRI) is open to visitors with prior appointments only. No external person(s) or agency can make any arrangement on their own.

Groups of school and college students (not more than 35 persons, including teacher/faculty at one time) for visits are encouraged.



Indian Academy of Sciences

<https://www.ias.ac.in/>



The Academy building, erected by Sir C V Raman, is located in the campus of the Raman Research Institute in Bengaluru.

Founded in 1934 by Sir C V Raman the Indian Academy of Sciences, Bangalore was registered as a Society on 27 April 1934 with the main objective of promoting the progress and upholding the cause of science. The Academy began functioning with 65 Founding Fellows and the formal inauguration took place at the Indian Institute of Science.

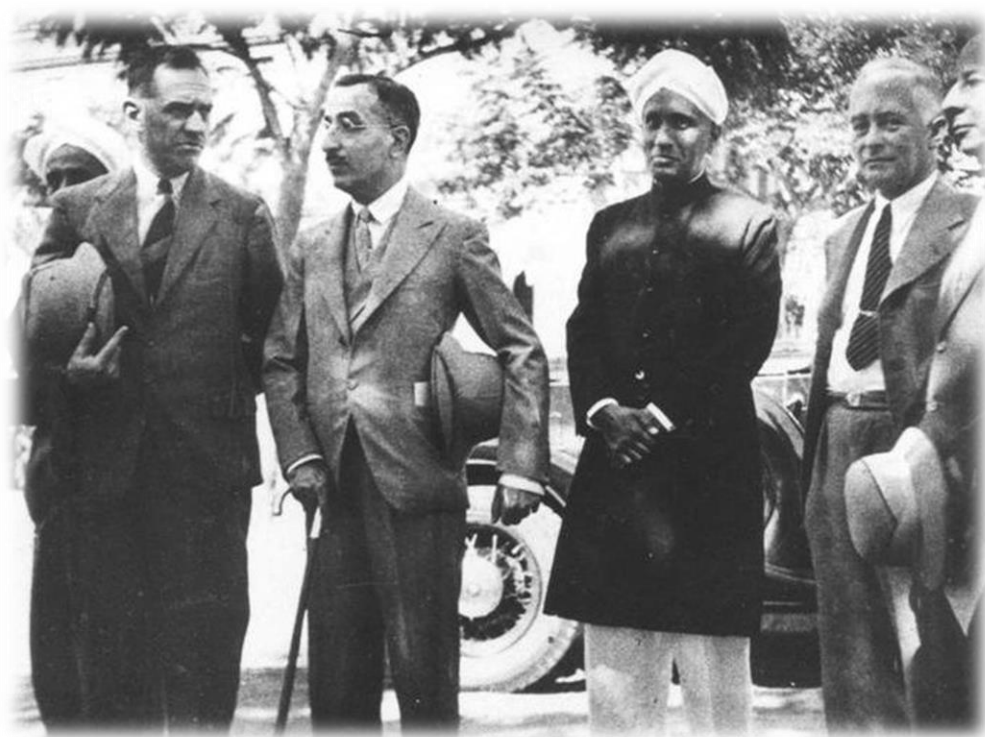
On the same afternoon its first general meeting of Fellows was held during which Sir C V Raman was elected President and the draft resolution of the Academy was adopted.

In the same month of 1934, the first issue of the Academy's earliest publication was published. The Academy from its very beginnings has taken great interest and initiative in publishing science research and today publishes 10 science journals in different disciplines, uses an

online submission and review management system that's trackable, papers are peer reviewed and published content is made available online and open access.

The Academy's contribution to science and society is also reflected through its policies, values and its range of activities which include:

[The Academy Fellowship](#) ● [Annual and Mid-Year Meetings](#) ● [Science Education Programmes](#) ● [Sponsorship of Discussion Meetings](#) ● [The Women in Science Panel](#) ● [Repository of Scientific Publications of Academy Fellows](#) ● [Oral History Archives](#) ● [Committee on Scientific Values](#) ● [Raman Chair Professorship](#) ● [Jubilee Chair Professorship](#) ● [Publications of the Academy](#) ● Contributions to Science Policy



Prof Raman with Sir Mirza Ismail at the Inaugural Meeting of the Academy at Bengaluru, on 31 July 1934

The Academy presently has 1077 Fellows,
57 Honorary Fellows, and 59 Associates on its rolls.

Past Presidents:

1934 - 1970

Prof. C. V. Raman

1971 - 1973

Prof. T. S. Sadasivan

1974 - 1976

Prof. M. G. K. Menon

1977 - 1979

Prof. S. Dhawan

1980 - 1982

Dr. S. Varadarajan

1983 - 1985

Prof. S. Ramaseshan

1986 - 1988

Prof. O. Siddiqi

1989 - 1991

Prof. C. N. R. Rao

1992 - 1994

Prof. R. Narasimha

1995 - 1997

Prof. P. Rama Rao

1998 - 2000

Prof. N. Kumar

2001 - 2003

Dr K. Kasturirangan

2004 - 2006

Prof. T. V. Ramakrishnan

2007 - 2009

Prof. D. Balasubramanian

2010 - 2012

Prof. A. K. Sood

2013 - 2015

Prof. Dipankar Chatterji

2016 - 2018

Prof. Ramakrishna Ramaswamy

Role of the Academy

Science has emerged today as the most revolutionary co-operative activity of mankind. In the scientific method lies a validity and universality which transcends any other principle devised by man. Science seeks and discovers, cutting across sectarian, national and ideological frontiers. It fosters co-operation and generates a value system which nurtures man's highest capabilities and aspirations.

The Indian Academy of Sciences, founded in 1934 by Professor C.V. Raman, Nobel Laureate, endeavours by all means at its disposal to promote the progress and uphold the cause of science, both in pure and applied branches. The Academy has laid the responsibility on all its Fellows, individually and collectively, of promoting original research and of disseminating scientific knowledge to the community, through its activities of organizing meetings, discussions, seminars, symposia and publications. The Academy recognizes the special relationship of scientific creative activity with the process of education and holds that the course of discovery includes the identification and nurturing of scientific talent amongst the young. Aware of the fundamental contributions science and technology can and must make to national regeneration, the Academy upholds that the principle of social responsibility for all scientific effort, individual or corporate, is entirely consistent with individual freedom and that the quest for knowledge and truth cannot be reconciled with any dogma.

In order to meet the needs of the times, the Council of the Academy has carefully considered the steps to be taken to further the objects of the Academy. Taking cognizance of the enormous and continuing increase in scientific knowledge and the application of this knowledge virtually to every sphere of human activity, and considering the growth of scientific activity within India and the numbers of scientific institutions and scientists working in various fields, the Council has, as a first step, expanded the Fellowship, in order to have within the Academy a fuller representation of the Indian scientific community in its corporate body so that the objectives and obligations of the Academy could be more effectively fulfilled. The other steps proposed are aimed at:

- ensuring that there is full representation in the Academy of all branches of science, fundamental and applied;
- placing special emphasis on bringing into the fold of the Academy, through election to the Fellowship, outstanding young scientists;
- promoting high quality journals in order to provide publication opportunities to Indian scientists at the international level;

- 
- conducting symposia and seminars and encouraging other similar activities in order to provide means of exchange of scientific knowledge among scientists and to bring new knowledge to the attention of the whole scientific community;
 - recognizing further, and honouring excellence in various areas of science by the institution of special awards (in the form of medals, lectureships, etc.);
 - giving special encouragement to young scientists by the award of scholarships and fellowships to enable them to pursue their particular interests;
 - promoting international understanding in science through the institution of special chairs and professorships, which will allow scientists from abroad to visit India for specific periods and provide means for travel for Indian scientists to visit other countries;
 - taking up integrated studies in specific fields where co-ordinated scientific activities tend to be neglected.

The Academy affirms that the rightful place for science and the men who rigorously cultivate it can be assured in society primarily through their devotion to the principles of objectivity, integrity and freedom from dogmas rather than through any formal processes of recognition. Not unmindful of the crucial role the Academy can play in national regeneration, the Academy adheres to the belief that this ideal would be best served by preserving the independence of the Academy from all official, State or Organization-related channels.

In a situation where almost every facet of life needs to be revitalized retaining a clear perspective for the nurturing of the scientific temper is of the utmost importance. In a country beset with prejudices, rules and bureaucratic formalisms, it is of the greatest value that working scientists, especially Fellows of the Academy, promote by personal as well as collective example, the principle of rational thought of function and relevance, rather than precedents. By applying rigorous standards of scientific criticism at all levels in a constructive sense, the Academy considers that the scientific community has a unique contribution to make not only to the flowering of science in India but also to national character.

Journals

Published by the Indian Academy of Sciences

Publication of scientific journals has been a major activity of the Academy since its formation in 1934 and the Proceedings of the Indian Academy of Sciences Part

A and Part B began publication that very year. The Academy today publishes 12 journals, several of which grew out of the original Proceedings.

In 1978, the Proceedings split into several themes and today these are Proceedings – Mathematical Sciences, Sadhana – Academy Proceedings in Engineering Sciences, Journal of Chemical Sciences, Journal of Earth System Science, and Journal of Biosciences. (there have been revisions to the journal names in the intervening years).

In 1985, the Academy took over publication of the Journal of Genetics, which is among the oldest English language journals in genetics, having been founded in 1910.

Journals that have been launched since then include Pramana – journal of Physics in 1973, Bulletin of Materials Science in 1979, Journal of Astrophysics and Astronomy in 1980, and Resonance – journal of science education in 1996.

The Academy also publishes two online-only journals – the Indian Academy of Sciences Conference Series (first online in December 2017) and DIALOGUE: Science, Scientists, and Society (first online in January 2018).

Our publication programme is guided by the principle that no journal published by the Academy should be in direct competition with other journals published in the country. To the extent possible, the Academy co-operates with other agencies in bringing out its journals, contributions to which are peer-reviewed.

Since 2007, ten of our journals are co-published with Springer [Springer Nature, since 2015].

Women in Science

An Indian Academy of Sciences Initiative



The issue of under representation of women in science is being seen with a great deal of concern all over the world. Over the years, several Academy Fellows had suggested

a need to address this concern. In order to examine and study – the current status with regard to women in science in the Indian context; the factors influencing the science career for Indian women; and to suggest recommendations, the Council of the Indian Academy of Sciences had in January 2003 constituted a committee on "Women in Science". This committee had come up with many initiatives and action plan for consideration by the Council and Fellowship. This led to the formation of the Panel for "Women in Science" (WiS), in January 2005, to carry out recommendations made by the committee and to suggest measures for obtaining suitable solutions.

The Panel is currently chaired by Prof. Sandhya S. Visweswariah. The Panel has undertaken several initiatives towards fulfilling its objectives.

Raman Chair

The Raman Chair was instituted in 1972 by the Government of India to commemorate the memory of the founder of the Academy, Sir C. V. Raman. Eminent scientists are invited by the Council of the Academy to occupy the Chair, for periods of between six weeks and six months.

Raman Professors who have occupied the Chair are:

Jul. - Oct. 1974

Prof. R. Hanbury Brown*, F.R.S.
University of Sydney (Australia)

Feb. - Mar. 1979 and Nov. 1979

Prof. Dorothy Hodgkin* Nobel Laureate
University of Oxford (UK)

Sep. - Dec. 1979

Prof. N. Bloembergen, Nobel Laureate
Harvard University, Cambridge (USA)

Dec. 1979 - Feb. 1980

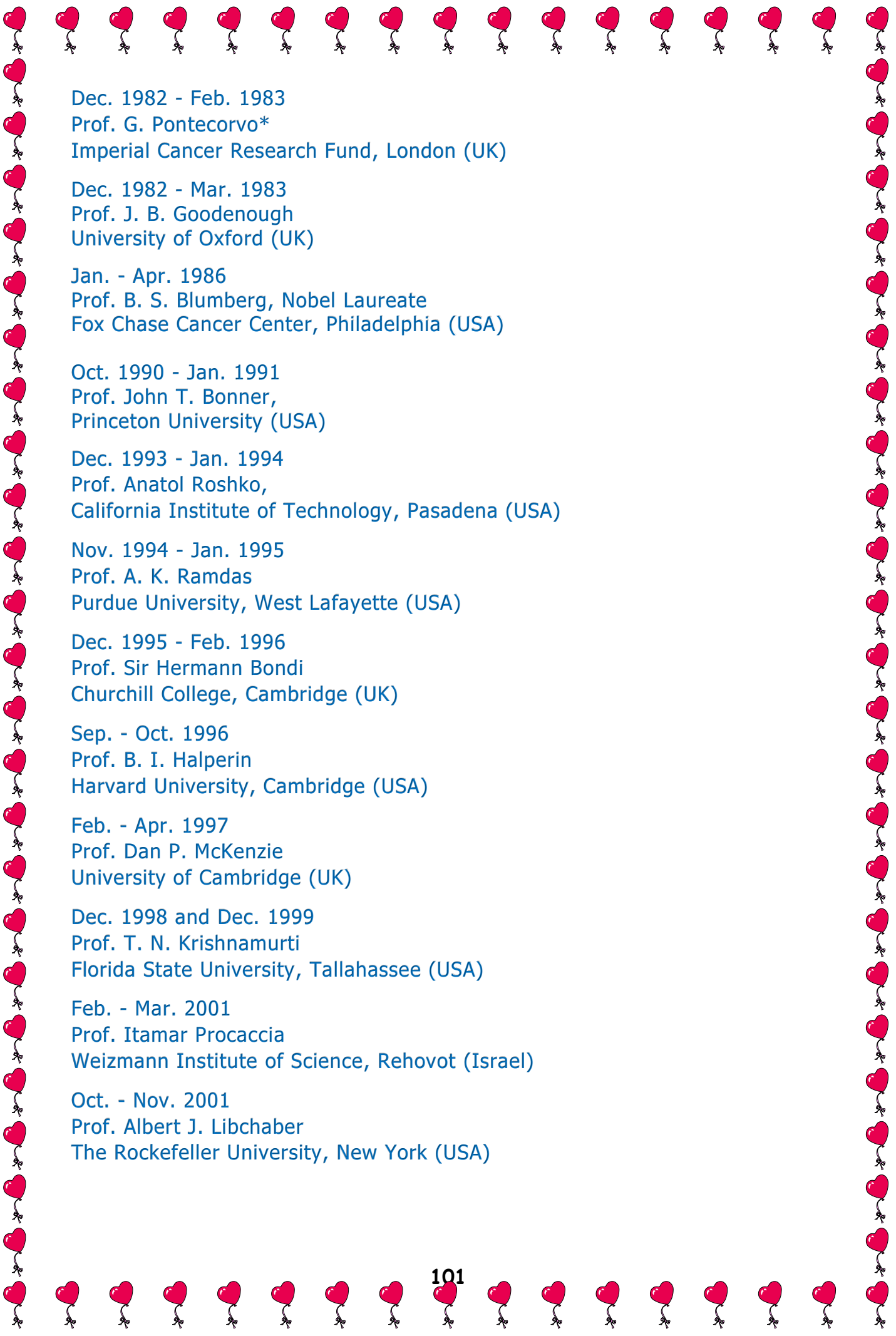
Prof. Charles Frank*
University of Bristol (UK)

Sep. - Dec. 1980

Prof. K. R. Ramanathan*
Physical Research Laboratory, Ahmedabad (India)

Oct. 1982 - Feb. 1983

Prof. George W. Series*
University of Reading (UK)



Dec. 1982 - Feb. 1983
Prof. G. Pontecorvo*
Imperial Cancer Research Fund, London (UK)

Dec. 1982 - Mar. 1983
Prof. J. B. Goodenough
University of Oxford (UK)

Jan. - Apr. 1986
Prof. B. S. Blumberg, Nobel Laureate
Fox Chase Cancer Center, Philadelphia (USA)

Oct. 1990 - Jan. 1991
Prof. John T. Bonner,
Princeton University (USA)

Dec. 1993 - Jan. 1994
Prof. Anatol Roshko,
California Institute of Technology, Pasadena (USA)

Nov. 1994 - Jan. 1995
Prof. A. K. Ramdas
Purdue University, West Lafayette (USA)

Dec. 1995 - Feb. 1996
Prof. Sir Hermann Bondi
Churchill College, Cambridge (UK)

Sep. - Oct. 1996
Prof. B. I. Halperin
Harvard University, Cambridge (USA)

Feb. - Apr. 1997
Prof. Dan P. McKenzie
University of Cambridge (UK)

Dec. 1998 and Dec. 1999
Prof. T. N. Krishnamurti
Florida State University, Tallahassee (USA)

Feb. - Mar. 2001
Prof. Itamar Procaccia
Weizmann Institute of Science, Rehovot (Israel)

Oct. - Nov. 2001
Prof. Albert J. Libchaber
The Rockefeller University, New York (USA)



Jun. - Jul. 2002

Prof. K. R. Sreenivasan
University of Maryland, College Park (USA)

Feb. - Mar. 2003

Prof. Philippe Nozieres
Institut Laue-Langevin, Grenoble Cedex (France)

Dec. 2003 - Jan. 2004

Prof. Robert Williams
Space Telescope Science Institute, Baltimore (USA)

Dec. 2004 - Jan. 2005

Prof. Abhay Ashtekar
Pennsylvania State University, University Park (USA)

Nov. - Dec. 2005 and Oct. - Nov. 2006

Prof. Anne McLaren*
Cancer Research UK, Gurdon Institute, Cambridge (UK)

Dec. 2007 - Jan. 2008

Prof. Sajeew John
University of Toronto, Toronto (Canada)

Jan. - Feb. 2009

Prof. S. R. S. Varadhan
Courant Institute, New York University, New York (USA)

Apr. 2009 and Oct. - Nov. 2009

Prof. Marc Fontecave Université
Joseph Fourier, Grenoble (France)

Jul. - Sep. 2010

Prof. Huzihiro Araki
Research Institute for Mathematical Sciences
Kyoto University, Kyoto (Japan)

Sep. - Oct. 2011 and Dec. 2011

Prof. Anthony K. Cheetham
University of Cambridge, Cambridge (UK)

Oct. 2011 and Jan. - Feb. 2012

Prof. Sauro Succi
Istituto Applicazioni Calcolo, Rome (Italy)

Feb. - Mar. 2014, Aug. - Sept. 2014 and Jan. 2015

Prof. Michael L. Klein
Temple University, Philadelphia (USA)

Feb. – Mar. 2016
Prof. T. J. Pedley
University of Cambridge, Cambridge (UK)

Dec. 2018 - Jan. 2019
Prof. David Baker
University of Washington, Seattle, USA

March 2019
Prof. Ben L Feringa
University of Groningen, The Netherlands

Jubilee Chair

The Jubilee Professorship was instituted during the Platinum Jubilee Year of the Academy (2009). General guidelines are as follows:

1. Eminent scientists from any country and from any scientific discipline can be invited to occupy the Jubilee Professorship for a minimum period of two weeks and up to one month.
2. The Jubilee Professor may pursue any scientific activity and may be based in any laboratory or Institution in India. The Professor is expected to visit smaller towns, universities for delivering lectures, holding seminars and interacting with students, teachers and researchers or for scientific collaboration.
3. The Jubilee Professor is entitled to an honorarium of Rs 80,000/- per month in addition to local hospitality for the Jubilee Professor and spouse/companion.
4. The Academy will provide one business class airfare from the place of residence to India and back or two economy class excursion fares if accompanied by spouse/companion.
5. All travel expenses of the Jubilee Professor within India will be met by the Academy.

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Raman Science Centre

<https://rscnagpur.gov.in/>



The Raman Science Centre Nagpur is an interactive science centre affiliated with Nehru Science Centre Mumbai. The centre was developed to promote a scientific attitude, portray the growth of science and technology and their applications in industry and human welfare, and hold science exhibits. The centre is named after famous Nobel Prize winner Indian physicist Chandrasekhara Venkata Raman. The Raman Science Centre was inaugurated on 7 March 1992 and the planetarium was started on 5 January 1997.

It is an exciting world on the bank of Gandhi Sagar. Here Science is no more a subject but an experience. Here science is a thing to play with & learn. Here one is free to spend a whole day in play with hands-on exhibits-press lever, turn wheels, roll balls, pull strings, press the buttons, look through the peepholes to make science work & enjoy. One can discover that, here concept of science is different: It is sheer fun.

The Raman Science Centre, Nagpur is a constituent unit of
National Council of Science Museums, Kolkata,
Working under the aegis of Ministry of Culture, Govt. of India.

This centre is established in the year 1989 for popularisation of
Science among masses and students in particular of
Vidarbha region. The name Raman was given due to the fact
the Sir C. V. Raman, first Indian Nobel laureate in Physics,
who has a Nagpur connection while he was associated
with Auditor general's office in Nagpur.

Our Objectives

- To Portray the growth of Science & Technology and their application in Industry and Human welfare, with a view to develop scientific attitude and temper and to create, inculcate and sustain a general awareness amongst the people.
- To popularise Science and Technology in cities, urban and rural areas for the benefit of students and for the masses.
- To supplement Science education given in schools and colleges to foster the spirit of scientific enquiry and creativity among the students.
- To collect, restore and preserve important historical objects which represent landmark in the development of Science, Technology and Industry.
- To conduct research in Science and Technology in the areas pertaining to the activities of the council and to evaluate traditional Science and Technology in the light of modern scientific and technical concepts.
- To establish centres for development of Science exhibits and Demonstration aids.
- To render assistance to Universities, Technical institutions, Museums, Schools and Colleges or other bodies in planning and organising Science Museums and also in training of personnel for Museum profession.

3-D Science Show

With this unique facility one can experience viewing of 3-D films using a stereo projection system and specially aligned polarized spectacles. The objects on the screen will almost tickle your nose or animals leaping from the screen onto your lap will make you jump off the chair. Whatever be the scene on the screen you are sure to get excited. The show Timings: 12.00, 01.00 PM, 02.00 PM, 03.00 PM, 4.00 PM, 5.00 PM. Special shows arranged for the school group with more than 60 students.



Planetarium

The Science of astronomy emerged as a result of intense study of sky by mankind. With the progress of civilization newer and better than ever instruments were developed for astronomical observations which intensified star gazing and widened human knowledge on celestial bodies. The planetarium is equipped with state-of-the-art full dome digital video projection system in combination with opto-mechanical projector is surely to take people to journey in the sky with immersive effect.

Currently Showing: Sun : Our Living Star A 25 minute show projecting dynamic story of Sun. The planetarium show reveals the secrets of the hot giant. The show explains how the Sun was formed billions of years ago and is still pouring its energy on us. How the matter is converted into energy in its core and how one day this enormous star will conclude life on Earth. The show is conducted in both Hindi and English language.

The show Timings: 12.00, 01.00 PM, 02.00 PM, 03.00 PM, 4.00 PM, 5.00 PM. Special shows arranged for the school group with more than 100 students.



Science Park

A large Science Park, sprawling over 6 acres of lush green beautiful landscape provides the visitors with an opportunity to relax in colourful surroundings, away from the hustle & bustle of the city life and allows the children to play with an array of outdoor exhibits on physical science. Pet animal cages, aviaries and Medicinal Plant Garden also enrich the environment. It is a lifetime experience of learning while playing in an open yard.

Pre-historic Animal Park

This is a 3-dimensional exposition that enthrals the visitors by taking back to pre-historic era in which different species of animals lived in the sea as well as on the land about 500 to 10,000 million years ago. During day time it is open for students but in the evening a light & sound show is also organized. It is built over an area of 2 acres and first of its kind in the central India.

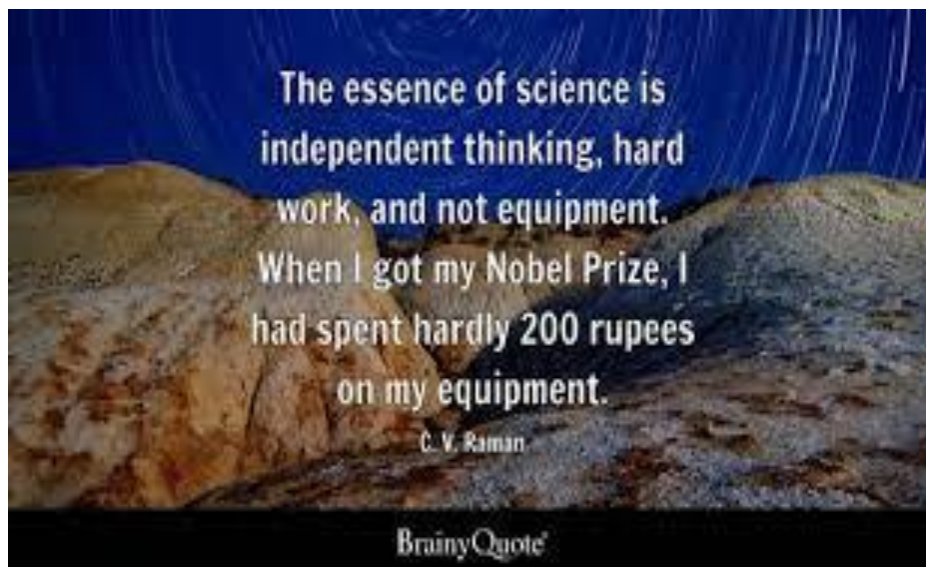
Auditorium

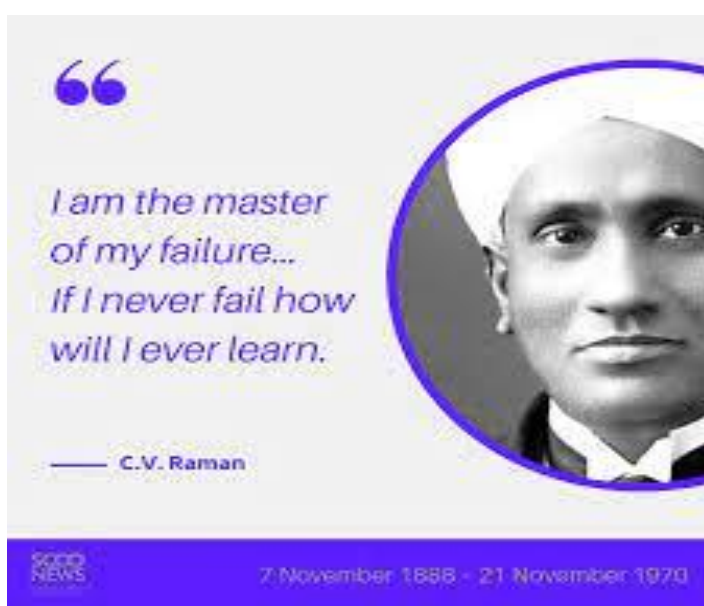
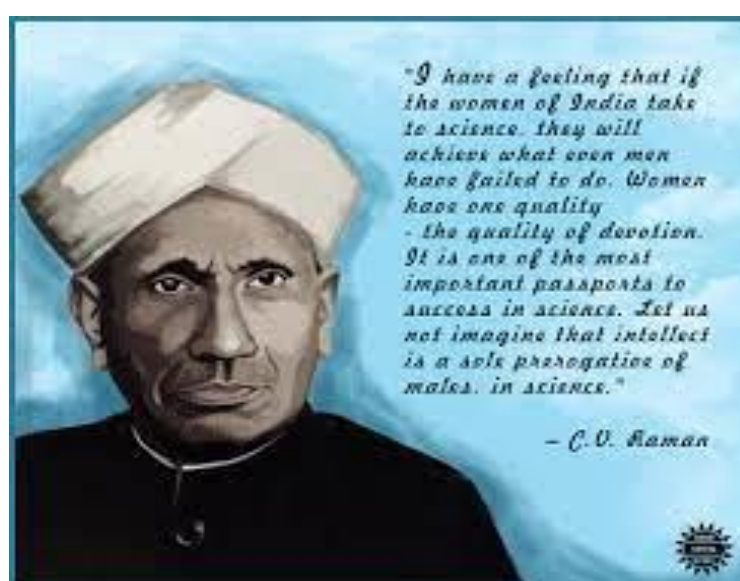
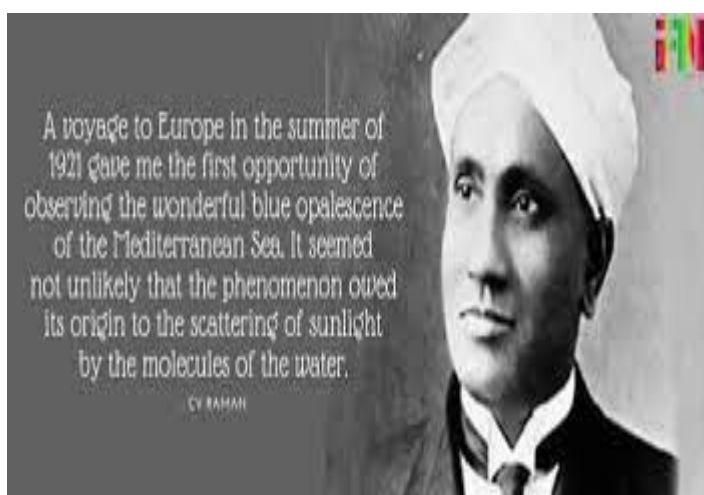


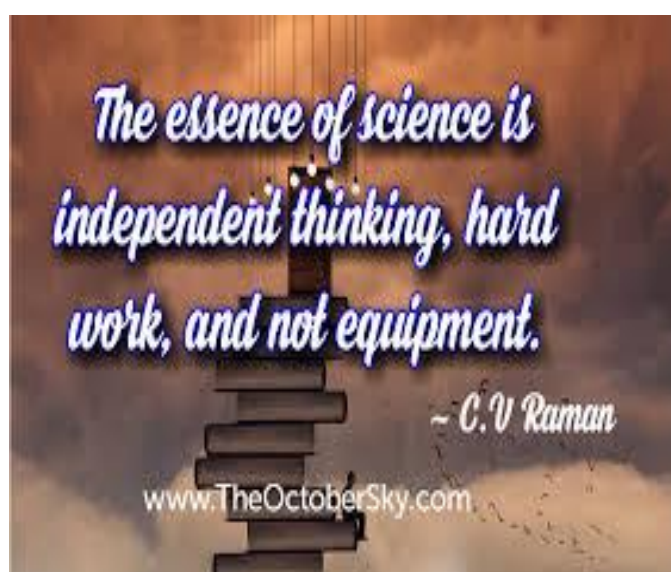
QUOTES

of

Sir CV Raman



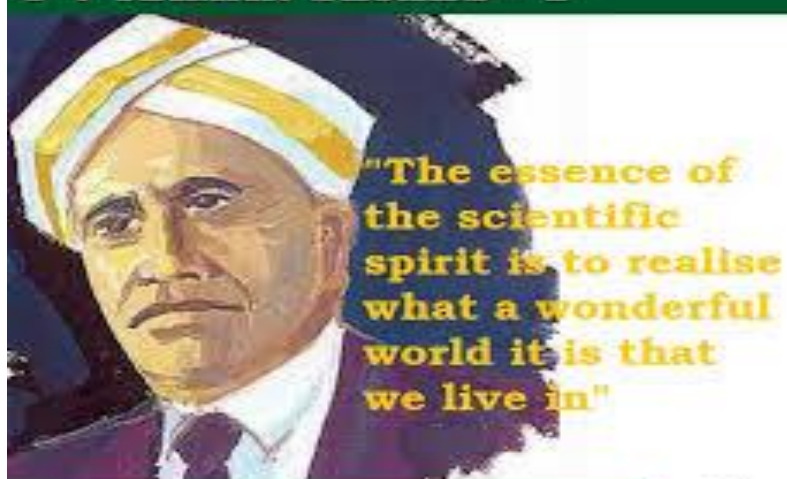




*"Ask the right questions, and
nature will open the doors to her
secrets."*

C.V. Raman

C V RAMAN SERIES - 1



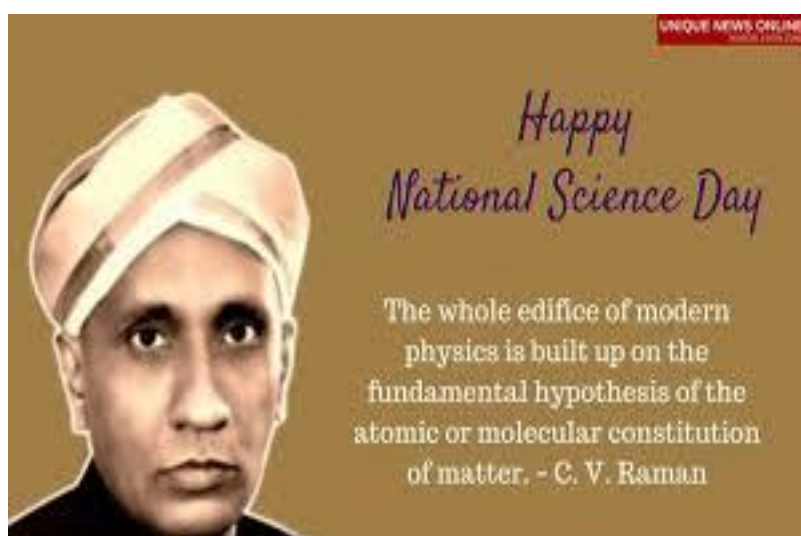
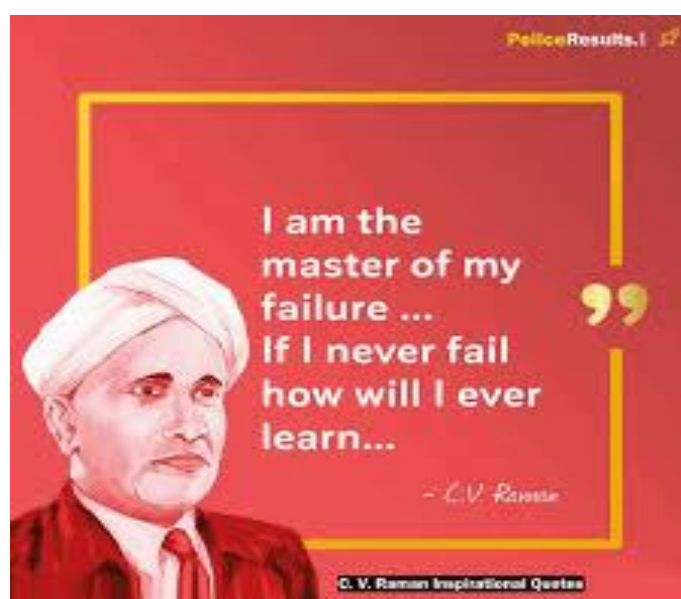
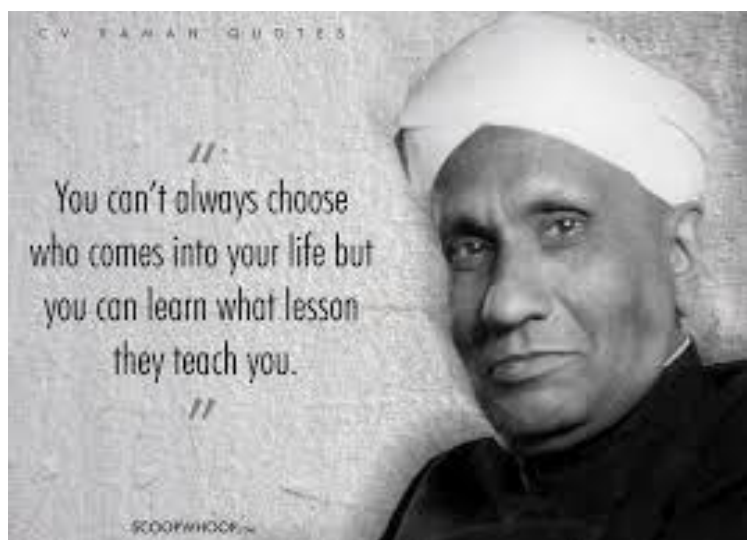
**"The essence of
the scientific
spirit is to realise
what a wonderful
world it is that
we live in"**

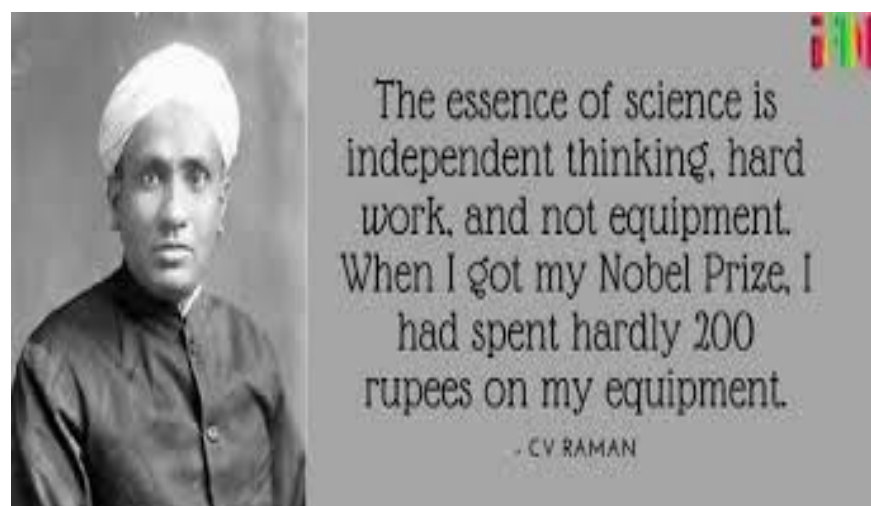
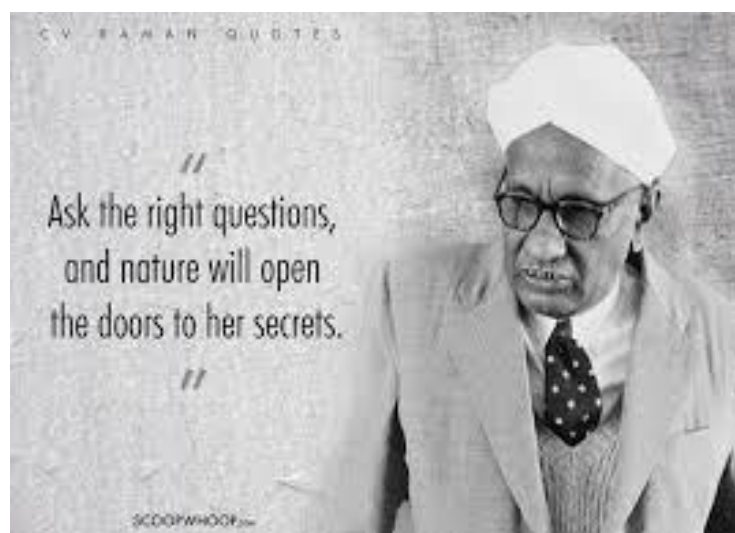
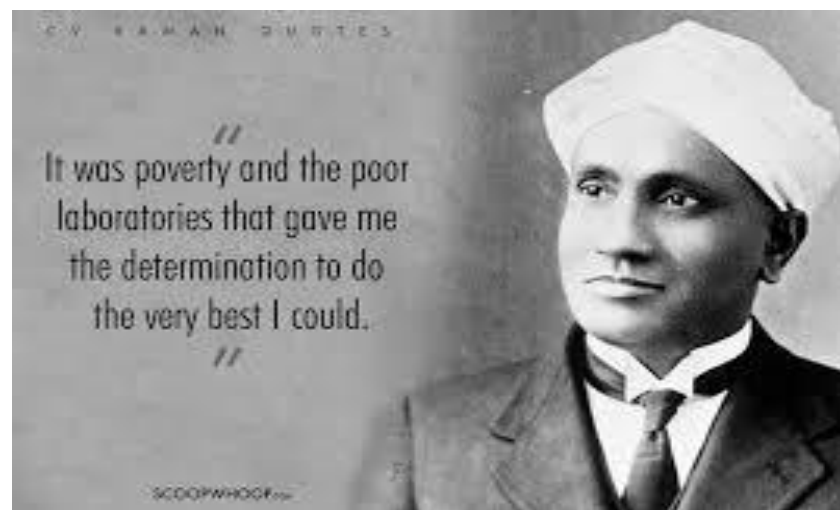
Creating a thinking generation!
facebook.com/EZVidya

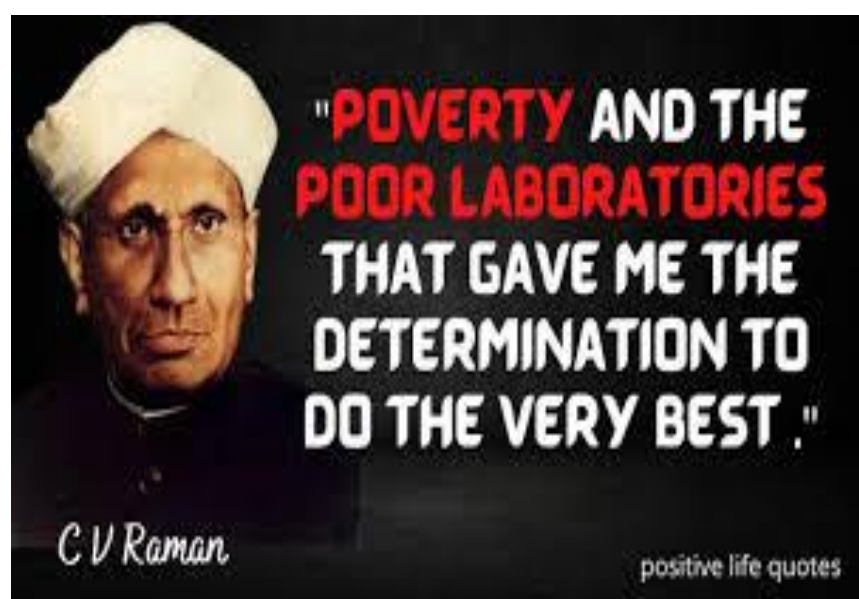
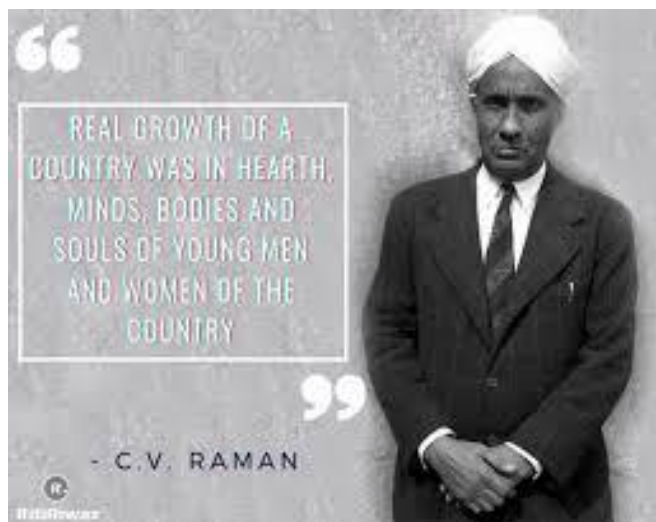
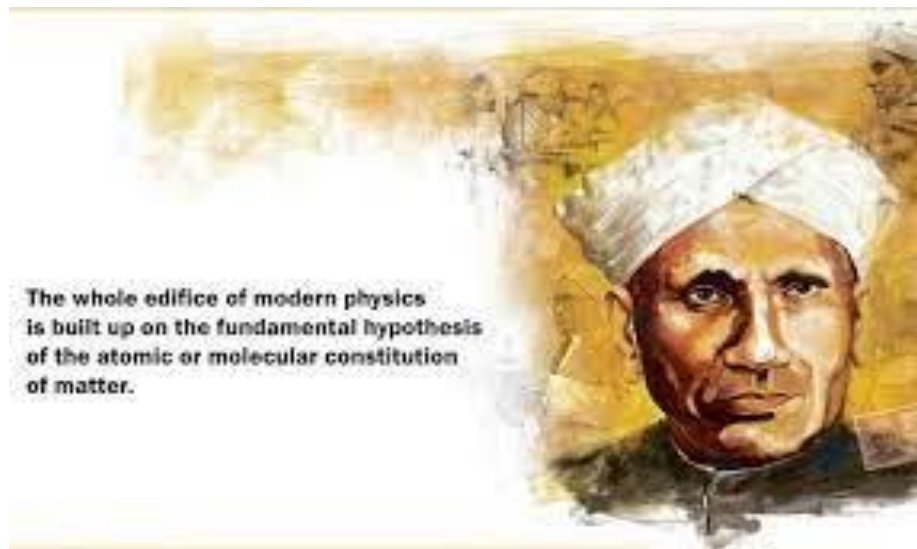


Success can come
to you by courageous
devotion to the task
lying in front of you.

CV Raman







National Science Day



National Science Day

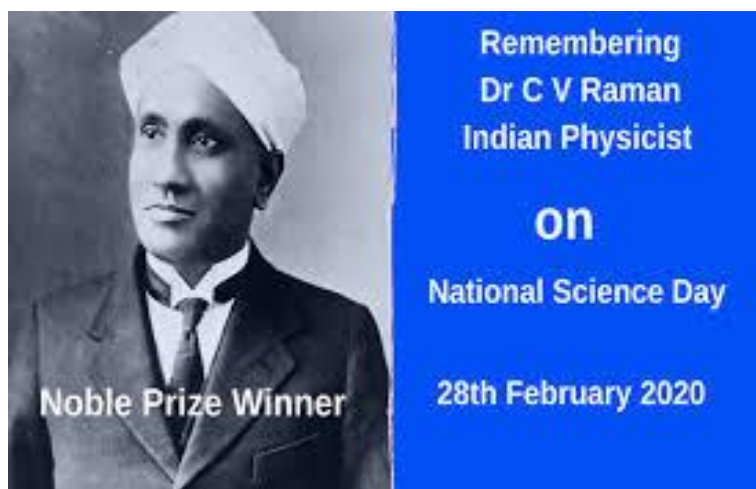
One might be aware that 28th February is celebrated as **National Science Day** in India. On this day in 1928, celebrated Indian Scientist Sir Chandrasekhara Venkata Raman discovered a phenomenon of scattering of photons which was later known as 'Raman Effect' after his name. After two years in 1930, he got Nobel Prize for this remarkable discovery and this was the first Nobel Prize for India in the field of Science. To mark the discovery of his famous phenomenon National Science Day is celebrated in India on the day each year.

When was the day declared as National Science Day?

In 1986, the National Council for Science and Technology Communication (NCSTC) asked the Government of India to designate 28 February as National Science Day which the then Govt. of India accepted and declared the day as National Science Day in 1986. The first National Science Day was celebrated on February 28, 1987.

Every year, the day is celebrated with different themes to raise awareness about the importance of science in everyday life. The themes have ranged from waste management to information technology to GM crops.

The celebration also includes public speeches, radio, TV, science movies, science exhibitions, research demonstration, debates, and many more activities.

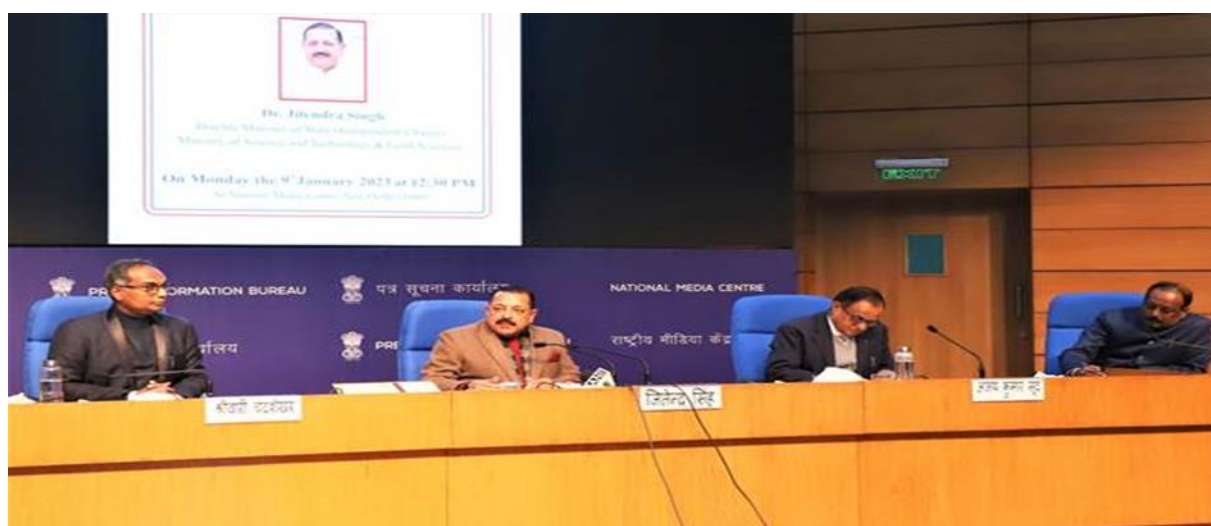


THEMES FOR NATIONAL SCIENCE DAY SINCE 1999

- 1999:** Our Changing Earth
- 2000:** Recreating Interest in Basic Science
- 2001:** Information Technology for Science Education
- 2002:** Wealth from Waste
- 2003:** 25 years of IVF and 50 years of DNA
- 2004:** Encouraging Scientific Awareness in Community
- 2005:** Celebrating Physics
- 2006:** Nurture Nature for our future
- 2007:** More Crop Per Drop
- 2008:** Understanding the Planet Earth
- 2009:** Expanding Horizons of Science
- 2010:** Science & Technology for Sustainable Development
- 2011:** Chemistry in Daily Life
- 2012:** Clean Energy Options and Nuclear Safety
- 2013:** Genetically Modified Crops and Food Security
- 2014:** Fostering Scientific Temper
- 2015:** Science for Nation Building
- 2016:** Scientific Issues for Development of the Nation

2017: Science and Technology for Specially Abled Persons
2018: Science and Technology for a sustainable future
2019: Science for People, and People for Science
2020: Women in Science
2021: Future of STI: Impact on Education Skills and Work
2022: Integrated Approach in Science and Technology for Sustainable Future'.
2023: Global Science for Global Wellbeing

"National Science Day 2023"
"GLOBAL SCIENCE FOR GLOBAL WELLBEING"



Dr Manoranjan Mohanty, Head, NCSTC, DST and other Senior officials of the Ministry of Science and Technology took part in the event.

Union Minister of State (Independent Charge) Science & Technology; Minister of State (Independent Charge) Earth Sciences; MoS PMO, Personnel, Public Grievances, Pensions, Atomic Energy and Space, Dr Jitendra Singh today released the theme for the "National Science Day 2023", titled "Global Science for Global Wellbeing" at National Media Centre, here.

The Minister said, as India enters 2023, the theme indicates India's emerging global role and rising visibility in the international arena.

Dr Jitendra Singh expressed his deep gratitude to Prime Minister Narendra Modi for his meticulous guidance on the theme, subject and events of the National Science Day.

Dr Jitendra Singh said, the theme of "Global Science for Global Wellbeing" is perfectly in sync with India assuming the Presidency of G-20, where she will become the voice of the global south that is the developing countries of Asia, Africa and South America.

Dr Jitendra Singh said, India has acquired Global Visibility in the Comity of Nations under Prime Minister Modi and we are ready for Outcome oriented Global Collaboration to address the Global Challenges. He said, when concerns, challenges and benchmarks have assumed global dimensions, the redressal should also be of the global nature.

The National Science Day (NSD) is celebrated every year on 28 February to commemorate the discovery of the 'Raman Effect'. Government of India designated 28 February as National Science Day (NSD) in 1986. On this day Sir C.V. Raman announced the discovery of the 'Raman Effect' for which he was awarded the Nobel Prize in 1930. On this occasion, theme-based science communication activities are carried out all over the country.

Dr Jitendra Singh recalled that Modi had extended National Science Day greetings to all scientists and science enthusiasts last year and called for Global Good, when he said, "Let us reaffirm our commitment towards fulfilling our collective scientific responsibility and leveraging the power of science for human progress".

Dr Jitendra Singh informed that the Global Science for Global Wellbeing theme has been chosen for the purpose of raising public appreciation of the scientific issues in global context which is having a bearing upon global wellbeing.



He said, today, Indian scientific breakthroughs have reached from the lab to the land, indeed applications of science are being used by every household to bring "Ease of Living" for the common man. It also heralds a new era to provide opportunities to people and scientific fraternity in the country and abroad to come together, work together and experience the joy of doing science for the wellbeing of mankind, the Minister added.

Dr Jitendra Singh said, Science and Technology ecosystem in the country has made rapid strides in the last 8 and half years by initiating several new landmark reforms with far reaching implications for the country. He also reiterated the Government's stand that with renewed focus on Science, India is progressively marching towards becoming a global leader in industrialization and technological development. India's new plan, called Science, Technology, and Innovation Policy 2020, plans to promote Science more effectively and experts-driven, the Minister added.

Principal Scientific Advisor to the Government of India, Dr Ajay Kumar Sood explained the rationale behind the theme OF "Global Science for Global Wellbeing" and said in the wake of COVID-19, the World has become more closer to fight global challenges. Dr Sood also explained in detail that it was on February 28 in 1928 that iconic Indian physicist C.V. Raman made an important discovery, known as the Raman Effect. The discovery was that when a beam of coloured

light entered a liquid, a fraction of the light scattered by that liquid was of a different color. Raman showed that the nature of this scattered light was dependent on the type of sample present.

Secretary, Department of Science and Technology (DST) Shri S. Chandrasekhar in his welcome address said that celebrations of important Scientific Days with associated events bring scientific awareness in the community. Many institutions organise open houses for their laboratories and appraise students about career opportunities available in a particular research laboratory/institution. The Department of Science and Technology (DST) acts as a nodal agency to support, catalyse and coordinate celebration of the National Science Day throughout the country in scientific institutions, research laboratories and autonomous scientific institutions associated with the Department of Science and Technology. National Council for Science & Technology Communication (NCSTC), DST has supported various programmes countrywide through State S&T Councils & Departments for organisation of lectures, quizzes, open houses, etc.



When CV Raman denied a student admission in IISc because she was a woman

This article [Author: Ms Deepika] first appeared on [Connect](#), an initiative of the Archives and Publications Cell of the Indian Institute of Science.

Stories of sexism from the early days of India's premier science institute.

On the day Indian Institute of Science first opened its doors to students, as the Institute's Annual Report for 1911 tells us, one hostel block was ready for occupation. What the Annual Report doesn't mention, however, is that the "students' hostel" was only meant for men. In 1909, plans had been made for staff quarters, two blocks of student quarters, quarters for "servants, sweepers and maistries", and even quarters for police. But it would take around three more decades for a women's hostel to feature in the Institute's plans.

While there are no records specifically identifying the first woman to ever have enrolled at the Indian Institute of Science, or IISc, records from 1920 mention a "Miss M. M. Mehta", and those from 1922 a "Miss R. K. Christie". After a long spell, the next woman to be admitted to the Institute appears to be "Miss K. Bhagvat", who joined in 1933.

Kamala Bhagvat (also spelled Bhagwat), later Kamala Sohonie, had just graduated with a first-class degree from Bombay University when she sought admission to IISc as a research student in biochemistry. CV Raman, who was the Institute Director at the time, infamously denied

Sohonie entry because of her gender. It was only after great persistence from Sohonie and her family that he agreed to admit her, with humiliating restrictions. It was a slight that Sohonie never forgot.

Years later, at a function organised by the Indian Women Scientists' Association, she is reported to have said: "Though Raman was a great scientist, he was very narrow-minded. I can never forget the way he treated me just because I was a woman. This was a great insult to me. The bias against women was so bad at that time. What can one expect if even a Nobel laureate behaves in such a manner?"

Sohonie would leave IISc in 1936, and in 1939, she would go on to earn a PhD at Cambridge University. She is often referred to as the first Indian woman to receive a doctorate in science, but it was Janaki Ammal, a botanist, who earned a DSc (equivalent to a PhD) from the University of Michigan in 1931. Sohonie is also sometimes referred to as the first woman student to ever be admitted to IISc, but records of MM Mehta and RK Christie show that this isn't true.



Students outside the first women's hostel at IISc, C. 1945. (L-R) Rajeswari Chatterjee, Roshan Irani, M Premabai, Miriam George and Violet D'Souza.

Archives and Publications Cell, IISc

Raman, who in public championed women's education, didn't make life easy for the women who studied under him. He would eventually admit three women into his lab at IISc, but was strict about not allowing them to mix with their fellow male students, as his former student Anna Mani's account in *Dispersed Radiance: Caste, Gender, and Modern Science in India* by Abha Sur shows.

The late 1930s and the 1940s saw the entry of a few more women to IISc, which slowly drove the need to have more infrastructure for women - including accommodation and women's toilets. The first mention of the Ladies' Hostel in annual reports is in 1942, listed under expenses. M Visvesvaraya, President of IISc's Court at the time, mentions the hostel in his address to the Court the same year.

The first female faculty member at IISc appears to have been Dorothy Norris, appointed Reader in Applied Chemistry in 1917, and made Assistant Professor of Biochemistry the following year (she would go on to be Founder-Director of the Indian Lac Research Institute). Two other women, Dr H Kale and G Clairon, taught European languages. The first Indian woman member of faculty appears to have been Rajeswari Chatterjee, who was made Lecturer in the Department of Electrical Communication Engineering in 1953. She was also the first woman to chair a department at the Institute, heading Electrical Communication Engineering from 1979 to 1981. It is only after 2000 that more women were appointed department heads, although their numbers remain low.



This photo of the Department of Physics in 1975 with 78 people. It has only three women: "Miss S. S. Kulkarni" on the extreme left, "Dr. Mrs. Kumari Santosh" towards the right, and "Mrs. C. R. Varalakshmi" on the extreme right.

Photo credit: Archives and Publications Cell, IISc.

Gender imbalance

Some departments have always attracted more women – such as those in the Division of Biological Sciences. Some, as in the engineering stream, have very few. The departments of Aerospace Engineering and Mechanical Engineering, set up in the 1940s, both hired their first female member of faculty in the last decade. The Department of Mathematics currently has only one female member of faculty, and the Materials Engineering (previously, Metallurgy) Department is one of a few on campus that have never had women faculty members at all. Even today, the number of women in decision-making bodies such as IISc's Court and Council remains low. IISc has had very few women deans, and has never had a woman as its director. The latest issue of the campus publication *Kernel* shows that out of 42 faculty members hired in 2017-2018, only four are women.

Ahead of the Institute's centenary celebrations, IISc put together two documents - one in 2009 called "Down the Memory Lane: Recollections of IISc Alumni" published by the Alumni Association, and one in 2008 called "Reminiscences" published by APC. In these collections, we get glimpses of what it was like for women on campus. GV Kamala, who was at the Department of Management Studies from 1965 to 1975, describes the women's hostel as a "small house-like building" with a common room stocked with fruits and flowers sent over from the Raman Research Institute by Mrs Raman (whose portrait hung in the hostel), with a note attached, saying, "Help yourself".

DK Padma, who was at the Department of Inorganic and Physical Chemistry from 1967 to 1994, talks about her initial encounter with MRA Rao, the head of the department, who asked to meet her along with her husband and said she would be admitted on the condition that she completed the course of 5-6 years and did not have a child during that period, "as in giving me admission he was curtailing a boy's career". Revathi Narayan, who studied at the Molecular Biophysics Unit from 1974-'79, initially sought admission to the Department of Biochemistry, where she was asked, "So, you are married, will you leave half way to start a family?" She continues, "No doubt the learned Professor had decided that principles of 'equal opportunity' were best left in legal tomes like the Constitution of India and were not seriously meant to be put into practice!"

Kalyani Vijayan, who was at the Department of Physics in the 1960s, wrote that there were so few women at the time (around 30) that Nalini Dhawan, the director's wife, knew most of them individually. She also talks about "dear old Ganga", who did all of the housekeeping and even washed the students' clothes in the hostel. Ganga serves as

a reminder of all the other working women on campus - in housekeeping, landscaping, administration, finance, in the library and other non-science tasks - whose work has kept the Institute running, but whose names are rarely recorded.



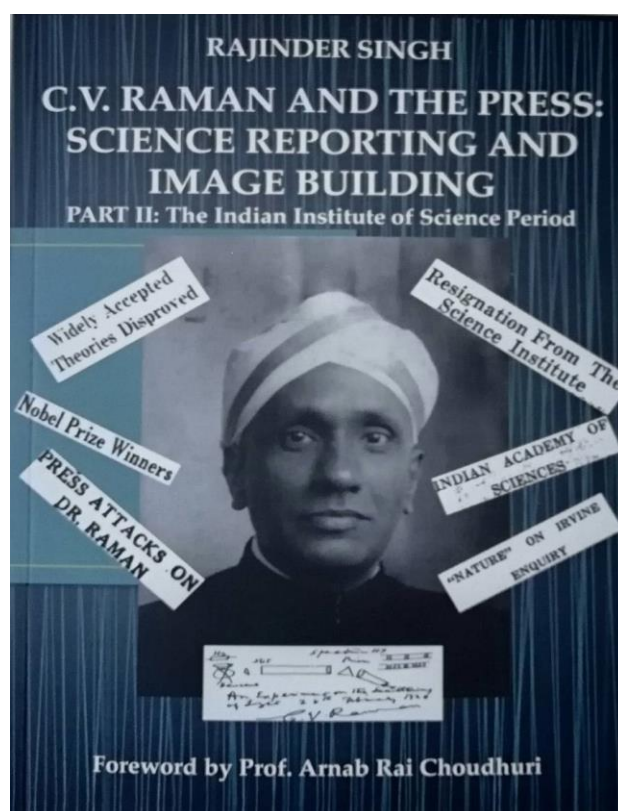
C V Raman & the Press

Author

Dr Anjana Chattopadhyay

Former Director, National Medical Library (MOH&FW, India) Former Director
General, Delhi Public Library System (MOC, India)

<https://indusscrolls.com/how-sir-c-v-raman-used-and-abused-press-for-his-advantage>



Rajinder Singh is a Germany-based well-known author, having credit of writing many biographies of scientists, especially physicists. He has written extensively on the life and work of one of the greatest physicists, Sir C V Raman. The first part of the series, *C V Raman and the Press*, traced Raman's most productive lifetime in Kolkata (1907- 33). The second part of the series focused on his service life as the Director of the Indian Institute of Science (IISc), Bangalore (1933-48). This period of his academic career was equally eventful as it was in Kolkata.

Raman will be remembered as a scientific genius having very complex personality. Many books and articles have been written on him, but the present volume revealed a very different side of his personality and explored his unique passion for use and abuse of his relations with the Press to enhance his personal image.

His temperamental ups and downs made his career challenging almost in every position he held and institutions he served. Visible conflicts between him and his peers surfaced everywhere.

Raman spent golden era of his life in Kolkata. He received very cordial atmosphere there and spent 25 years of his life in that city. Initially, he was virtually not known to the scientific world, when he was given opportunity to carry out his research activity at the Indian Association for the Cultivation of Science (IACS), Kolkata. On the basis of his scientific work, he was appointed as the Palit Professor of Physics at the Calcutta University. The Kolkata academia provided him all round support for his most significant discovery the "Raman's Effect" in 1928. Despite of having limited financial resources, he was given travel grant for Europe tour to initiate acceptance and understanding for his new discovery to the world community of science. His discovery created sensation in the world and he received the Nobel Prize for Physics in 1930. On his return from Stockholm with the Prize, he received royal welcome from scientists, government and public at Howrah, Kolkata. He was the first Asian to get Nobel Prize in science, which made him a world class celebrity.

His glorious accomplishments in Kolkata paved the way to be the Director of the Indian Institute of Sciences (IISc), Bangalore. The country and the government of that time cherished his scientific achievements as a national asset and it was expected that the future generation would draw inspiration from his leadership.

On March 31, 1933, C V Raman became the first Indian to join the prestigious position of Director of IISc. He was appointed as the Director and the Professor of Physics. At that time the IISc did not have the Physics Department and with his earnest effort, the Physics Department came into

being in July 1933. He got embroiled in a controversy, soon after his joining IISc, Bangalore. Within the six months of his service, two faculty members, Professor F N Mowdawalla and Dr. H E Watson resigned. At times he ignored rules and regulations, and even misinterpreted them as per his requirements. He made major administrative changes to divert funds from Chemistry and Engineering Departments to Physics. There was a rumor that the Director scared away brilliant students from joining other departments of the institute, except that of Physics. The institute started facing inner conflict and unrest among staff members, which created endless wrangles and research suffered.

The situation forced the authority to appoint a committee chaired by Sir James Irvin, Vice-Chancellor of the St. Andrew's University to look in to the affairs of IISc. The finding of the committee report mentioned that the Director's manner of handling the administration was not acceptable to others. Director lost confidence of the authority and the committee recommended for his suspension from the post of the Director. He was alienated and faced severe humiliation for his rebellious nature. It also recommended for the appointment of a new Registrar to look after the administration of the institute. He was forced to step down to the position of professor of Physics and his short tenure of Directorship came to an end in July 1937. He retired from IISc in 1948.

After the Bengal controversy, people thought that success always breeds envy. Maybe Raman was misunderstood and maligned because he was an outsider in Bengal. But unfortunately, his manner of handling situations in IISc, Bangalore also offended people, created instability and turmoil in academic environment. At times, he felt suffocated under government rules and regulations and he wanted autonomy and freedom for his research in physics. Therefore, he established Raman Research Institute (RRI), Bangalore with the help of donation from the Maharaja from Mysore. He shifted to RRI after his retirement in 1948 and served the institute till 1970, when he died. The forthcoming part of the series "C V Raman and the Press" Part-III will cover the last phase of his service life.

Raman was a scientific genius, gifted writer and a brilliant narrator, which further strengthened his bond with the media. He contributed extensively to many learned journals as well as popular magazines. He was a proficient speaker, who could explain most enigmatic scientific events in a language that ordinary people could understand. In those days radio was a powerful media and he made frequent radio talks, which made him popular and reachable to a spectrum of audience. He was an impatient scientist, who never waited for the Press to come to him; instead he provided updated Press reports of his research findings to them. His work on lattice dynamics was reported in Indian Press as a revolutionary scientific finding, but the same was rejected by the international Physics community. In those days because of his celebrated authority, the Indian Press believed and published whatever he informed them, without understanding the validity of facts. His association with correspondents was so close that he misused them for his career gain and at times he stymied them from reporting any controversy against him.

Raman was a unique personality having his weakness and strengths. He made towering contributions in the development of science in India. He will be remembered for making phenomenal scientific theories of different forms of diamond, 2 types of X-ray reflection, blue sky colour due to molecular scattering of light and creation of the Bangalore School of Physics, etc.

Refer to the other books on the same subject, including *Journey to Light: Life and Science of C V Raman* by G Venkataraman (1988) and *C V Raman: A Biography* by Uma Parameshwaran (2011), the present narrative is something new and different from what has been written earlier. Rajinder Singh has touched a sensitive theme very eloquently and elegantly. He has done thorough research on the subject and scanned books, journals, press clippings from various institutions, libraries and archives around the world.

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Awards & Honours

List of Awards, etc.,

- In 1912, Raman received the Curzon Research Award, while still working in the Indian Finance Service.
- In 1913, he received the Woodburn Research Medal, while still working in the Indian Finance Service.
- In 1928, he received the Matteucci Medal from the Accademia Nazionale delle Scienze in Rome.
- In 1930, he was knighted. An approval for his inclusion in the 1929 Birthday Honours was delayed, and Lord Irwin, the Viceroy of India, conferred him a Knight Bachelor in a special ceremony at the Viceroy's House (now Rashtrapati Bhavan) in New Delhi.
- In 1930, he won the Nobel Prize in Physics "for his work on the scattering of light and for the discovery of the effect named after him." He was the first Asian and first non-white to receive any Nobel Prize in the sciences. Before him, Rabindranath Tagore (also Indian) had received the Nobel Prize for Literature in 1913.
- In 1930, he received the Hughes Medal of the Royal Society.
- In 1941, he was awarded the Franklin Medal by the Franklin Institute in Philadelphia.
- In 1954, he was awarded the Bharat Ratna (along with politician and former Governor-General of India C. Rajagopalachari and philosopher Sir Sarvepalli Radhakrishnan).
- In 1957, he was awarded the Lenin Peace Prize.

Posthumous Recognitions:

- India celebrates National Science Day on 28 February of every year to commemorate the discovery of the Raman effect in 1928.
- Postal stamps featuring Raman were issued in 1971 and 2009.
- A road in India's capital, New Delhi, is named C. V. Raman Marg.
- An area in eastern Bangalore is called CV Raman Nagar.
- The road running north of the national seminar complex in Bangalore is named C. V. Raman Road.
- A building at the Indian Institute of Science in Bangalore is named the Raman Building.
- A hospital in eastern Bangalore on 80 Ft. Rd. is named the Sir C. V. Raman Hospital.
- There is also CV Raman Nagar in Trichy, his birthplace.
- Raman, a lunar crater is named after C. V. Raman.
- C. V. Raman Global University was established in 1997.
- In 1998, the American Chemical Society and Indian Association for the Cultivation of Science recognised Raman's discovery as an International Historic Chemical Landmark at the Indian Association for the Cultivation of Science in Jadavpur, Calcutta, India.
- Dr. C.V. Raman University was established in Chhattisgarh in 2006.
- On 7 November 2013, a Google Doodle honoured Raman on the 125th anniversary of his birthday.
- Raman Science Centre in Nagpur is named after Sir C. V. Raman.
- Dr. C.V. Raman University, Bihar was established in 2018.
- Dr. C.V. Raman University, Khandwa was established in 2018.

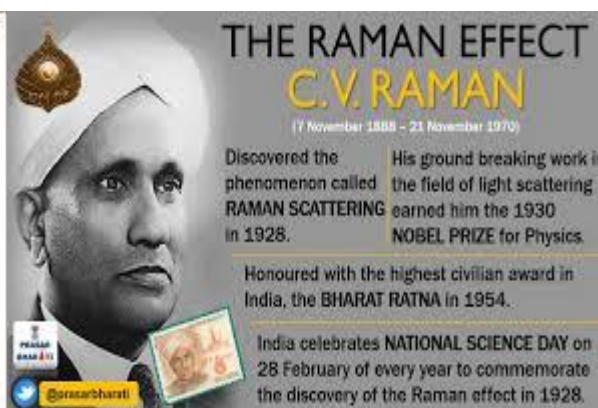
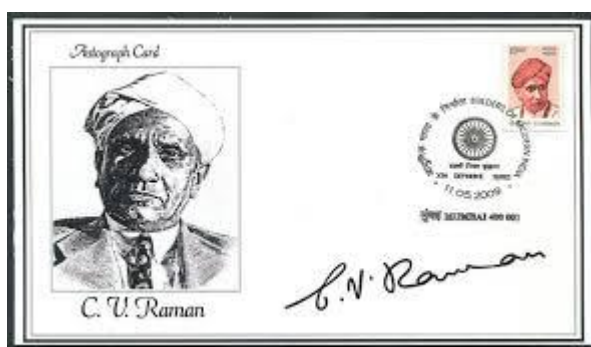


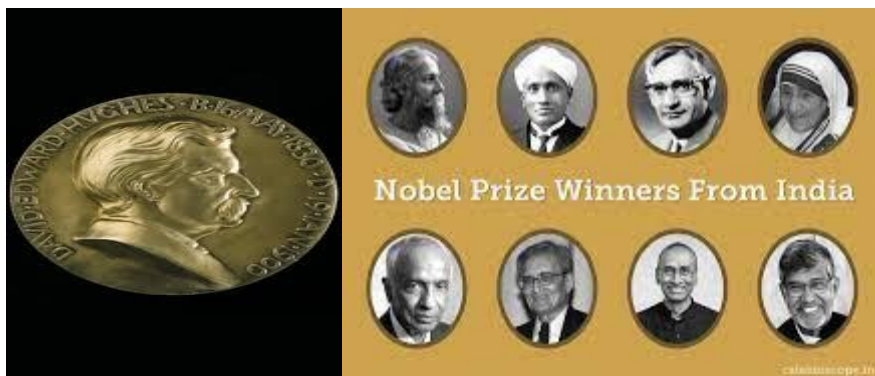
Bust of CV Raman in the garden of Birla Industrial & Technological Museum.

Fellowships/Memberships

- ❖ Fellow of the Royal Society
- ❖ President of the Indian Academy of Sciences (FASc)
- ❖ Fellow of the Asiatic Society of Bengal (FASB)
- ❖ Foundation Fellow of the Indian Association for the Cultivation of Science (FIAS)
- ❖ Foundation Fellow of the National Institute of Sciences of India (FNI, now the Indian National Science Academy)
- ❖ Member of the Deutsche Akademie of Munich
- ❖ Fellow of the Swiss Physical Society of Zürich
- ❖ Fellow of the Hungarian Academy of Sciences
- ❖ Fellow of the Academy of Sciences of the USSR
- ❖ Fellow of the Optical Society of America
- ❖ Fellow of the Mineralogical Society of America
- ❖ Fellow of the Romanian Academy of Sciences
- ❖ Fellow of the Catgut Acoustical Society of America
- ❖ Fellow of the Czechoslovak Academy of Sciences







Nobel Prize



About the Prize

"The said interest shall be divided into five equal parts, which shall be apportioned as follows: /- - / one part to the person who shall have made the most important discovery or invention within the field of physics ..."

(Excerpt from the will of Alfred Nobel)

Physics was the prize area which Alfred Nobel mentioned first in his will from 1895. At the end of the nineteenth century, many people considered physics as the foremost of the sciences, and perhaps Nobel saw it this way as well. His own research was also closely tied to physics.

The Nobel Prize in Physics is awarded by the Royal Swedish Academy of Sciences, Stockholm, Sweden.

The Nobel Prize in Physics has been awarded 116 times to 222 Nobel Prize laureates between 1901 and 2022. John Bardeen is the only laureate who has been awarded the Nobel Prize in Physics twice, in 1956 and 1972. This means that a total of 221 individuals have received the Nobel Prize in Physics. Click on the links to get more information.

Award money

At the awards ceremony, the laureate is given a document indicating the award sum. The amount of the cash award may differ from year to year, based on the funding available from the Nobel Foundation. For example, in 2009 the total cash awarded was 10 million SEK (US\$1.4 million), but in 2012 following the Great Recession, the amount was 8 million Swedish Kronor, or US\$1.1 million. If there are two laureates in a particular category, the award grant is divided equally between the recipients, but if there are three, the awarding committee may opt to divide the grant equally, or award half to one recipient and a quarter to each of the two others.

Ceremony

The committee and institution serving as the selection board for the prize typically announce the names of the laureates during the first week of October. The prize is then awarded at formal ceremonies held annually in Stockholm Concert Hall on 10 December, the anniversary of Nobel's death. The laureates receive a diploma, a medal and a document confirming the prize amount.

Awarded the first Nobel Prize in Physics, Wilhelm Röntgen discovered X-radiation. This X-ray tube became a frequently used instrument in medicine after this discovery.

Please visit this web link to know more:

<https://www.nobelprize.org/prizes/lists/all-nobel-prizes-in-physics/>

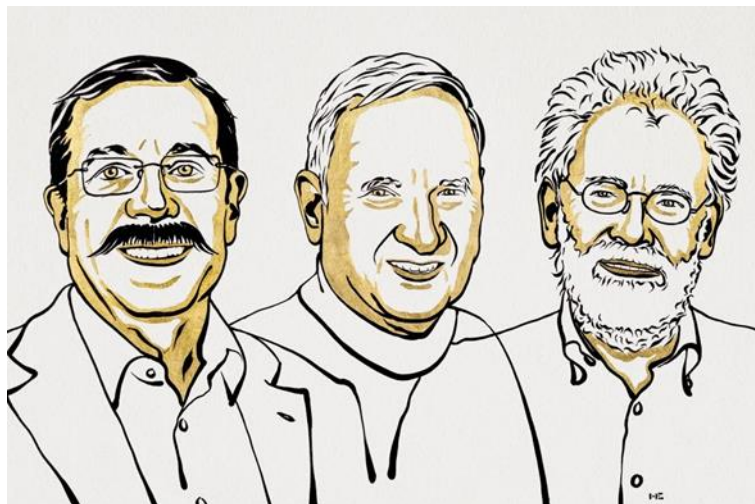
The 2022 physics laureates

The Nobel Prize in Physics 2022 was awarded to

[Alain Aspect](#), [John F. Clauser](#) and [Anton Zeilinger](#)

"for experiments with entangled photons, establishing the violation of Bell inequalities and pioneering quantum information science".

Their results have cleared the way for new technology
based upon quantum information.



The Nobel Prize in Physics 2022

Alain Aspect

Prize share: 1/3

John F. Clauser

Prize share: 1/3

Anton Zeilinger

Prize share: 1/3

The Nobel Prize in Physics 2021

"for ground breaking contributions to our understanding of complex systems"

Syukuro Manabe and Klaus Hasselmann "for the physical modelling of Earth's climate, quantifying variability and reliably predicting global warming"

Giorgio Parisi "for the discovery of the interplay of disorder and fluctuations in physical systems from atomic to planetary scales"

The Nobel Prize in Physics 2020

Roger Penrose "for the discovery that black hole formation is a robust prediction of the general theory of relativity"

Reinhard Genzel and Andrea Ghez "for the discovery of a supermassive compact object at the centre of our galaxy"

The Nobel Prize in Physics 2019

"for contributions to our understanding of the evolution of the universe and Earth's place in the cosmos"

James Peebles "for theoretical discoveries in physical cosmology"

Michel Mayor and Didier Queloz "for the discovery of an exoplanet orbiting a solar-type star"

The Nobel Prize in Physics 2018

"for groundbreaking inventions in the field of laser physics"

Arthur Ashkin "for the optical tweezers and their application to biological systems"

Gérard Mourou and Donna Strickland "for their method of generating high-intensity, ultra-short optical pulses"

The Nobel Prize in Physics 2017

Rainer Weiss, Barry C. Barish and Kip S. Thorne "for decisive contributions to the LIGO detector and the observation of gravitational waves"

The Nobel Prize in Physics 2016

David J. Thouless, F. Duncan M. Haldane and J. Michael Kosterlitz "for theoretical discoveries of topological phase transitions and topological phases of matter"

The Nobel Prize in Physics 2015

Takaaki Kajita and Arthur B. McDonald "for the discovery of neutrino oscillations, which shows that neutrinos have mass"

The Nobel Prize in Physics 2014

Isamu Akasaki, Hiroshi Amano and Shuji Nakamura "for the invention of efficient blue light-emitting diodes which has enabled bright and energy-saving white light sources"

The Nobel Prize in Physics 2013

François Englert and Peter W. Higgs "for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider"

The Nobel Prize in Physics 2012

Serge Haroche and David J. Wineland "for ground-breaking experimental methods that enable measuring and manipulation of individual quantum systems"

The Nobel Prize in Physics 2011

Saul Perlmutter, Brian P. Schmidt and Adam G. Riess "for the discovery of the accelerating expansion of the Universe through observations of distant supernovae"

The Nobel Prize in Physics 2010

Andre Geim and Konstantin Novoselov "for ground breaking experiments regarding the two-dimensional material graphene"

The Nobel Prize in Physics 2009

Charles Kuen Kao "for ground breaking achievements concerning the transmission of light in fibers for optical communication"

Willard S. Boyle and George E. Smith "for the invention of an imaging semiconductor circuit - the CCD sensor"

The Nobel Prize in Physics 2008

Yoichiro Nambu "for the discovery of the mechanism of spontaneous broken symmetry in subatomic physics"

Makoto Kobayashi and Toshihide Maskawa "for the discovery of the origin of the broken symmetry which predicts the existence of at least three families of quarks in nature"

The Nobel Prize in Physics 2007

Albert Fert and Peter Grünberg "for the discovery of Giant Magnetoresistance"

The Nobel Prize in Physics 2006

John C. Mather and George F. Smoot "for their discovery of the blackbody form and anisotropy of the cosmic microwave background radiation"

The Nobel Prize in Physics 2005

Roy J. Glauber "for his contribution to the quantum theory of optical coherence"

John L. Hall and Theodor W. Hänsch "for their contributions to the development of laser-based precision spectroscopy, including the optical frequency comb technique"

The Nobel Prize in Physics 2004

David J. Gross, H. David Politzer and Frank Wilczek "for the discovery of asymptotic freedom in the theory of the strong interaction"

The Nobel Prize in Physics 2003

Alexei A. Abrikosov, Vitaly L. Ginzburg and Anthony J. Leggett "for pioneering contributions to the theory of superconductors and super fluids"

The Nobel Prize in Physics 2002

Raymond Davis Jr. and Masatoshi Koshiro "for pioneering contributions to astrophysics, in particular for the detection of cosmic neutrinos"

Riccardo Giacconi "for pioneering contributions to astrophysics, which have led to the discovery of cosmic X-ray sources"

The Nobel Prize in Physics 2001

Eric A. Cornell, Wolfgang Ketterle and Carl E. Wieman "for the achievement of Bose-Einstein condensation in dilute gases of alkali atoms, and for early fundamental studies of the properties of the condensates"

The Nobel Prize in Physics 2000

"for basic work on information and communication technology"

Zhores I. Alferov and Herbert Kroemer "for developing semiconductor heterostructures used in high-speed- and optoelectronics"

Jack S. Kilby "for his part in the invention of the integrated circuit"

The Nobel Prize in Physics 1999

Gerardus 't Hooft and Martinus J.G. Veltman "for elucidating the quantum structure of electroweak interactions in physics"

The Nobel Prize in Physics 1998

Robert B. Laughlin, Horst L. Störmer and Daniel C. Tsui "for their discovery of a new form of quantum fluid with fractionally charged excitations"

The Nobel Prize in Physics 1997

Steven Chu, Claude Cohen-Tannoudji and William D. Phillips "for development of methods to cool and trap atoms with laser light"

The Nobel Prize in Physics 1996

David M. Lee, Douglas D. Osheroff and Robert C. Richardson "for their discovery of superfluidity in helium-3"

The Nobel Prize in Physics 1995

"for pioneering experimental contributions to lepton physics"

Martin L. Perl "for the discovery of the tau lepton"

Frederick Reines "for the detection of the neutrino"

The Nobel Prize in Physics 1994

"for pioneering contributions to the development of neutron scattering techniques for studies of condensed matter"

Bertram N. Brockhouse "for the development of neutron spectroscopy"

Clifford G. Shull "for the development of the neutron diffraction technique"

The Nobel Prize in Physics 1993

Russell A. Hulse and Joseph H. Taylor Jr. "for the discovery of a new type of pulsar, a discovery that has opened up new possibilities for the study of gravitation"

The Nobel Prize in Physics 1992

Georges Charpak "for his invention and development of particle detectors, in particular the multiwire proportional chamber"

The Nobel Prize in Physics 1991

Pierre-Gilles de Gennes "for discovering that methods developed for studying order phenomena in simple systems can be generalized to more complex forms of matter, in particular to liquid crystals and polymers"

The Nobel Prize in Physics 1990

Jerome I. Friedman, Henry W. Kendall and Richard E. Taylor "for their pioneering investigations concerning deep inelastic scattering of electrons on protons and bound neutrons, which have been of essential importance for the development of the quark model in particle physics"

The Nobel Prize in Physics 1989

Norman F. Ramsey "for the invention of the separated oscillatory fields method and its use in the hydrogen maser and other atomic clocks"

Hans G. Dehmelt and Wolfgang Paul "for the development of the ion trap technique"

The Nobel Prize in Physics 1988

Leon M. Lederman, Melvin Schwartz and Jack Steinberger "for the neutrino beam method and the demonstration of the doublet structure of the leptons through the discovery of the muon neutrino"

The Nobel Prize in Physics 1987

J. Georg Bednorz and K. Alexander Müller "for their important break-through in the discovery of superconductivity in ceramic materials"

The Nobel Prize in Physics 1986

Ernst Ruska "for his fundamental work in electron optics, and for the design of the first electron microscope"

Gerd Binnig and Heinrich Rohrer "for their design of the scanning tunneling microscope"

The Nobel Prize in Physics 1985

Klaus von Klitzing "for the discovery of the quantized Hall effect"

The Nobel Prize in Physics 1984

Carlo Rubbia and Simon van der Meer "for their decisive contributions to the large project, which led to the discovery of the field particles W and Z, communicators of weak interaction"

The Nobel Prize in Physics 1983

Subramanyan Chandrasekhar "for his theoretical studies of the physical processes of importance to the structure and evolution of the stars"

William Alfred Fowler "for his theoretical and experimental studies of the nuclear reactions of importance in the formation of the chemical elements in the universe"

The Nobel Prize in Physics 1982

Kenneth G. Wilson "for his theory for critical phenomena in connection with phase transitions"

The Nobel Prize in Physics 1981

Nicolaas Bloembergen and Arthur Leonard Schawlow "for their contribution to the development of laser spectroscopy"

Kai M. Siegbahn "for his contribution to the development of high-resolution electron spectroscopy"

The Nobel Prize in Physics 1980

James Watson Cronin and Val Logsdon Fitch "for the discovery of violations of fundamental symmetry principles in the decay of neutral K-mesons"

The Nobel Prize in Physics 1979

Sheldon Lee Glashow, Abdus Salam and Steven Weinberg "for their contributions to the theory of the unified weak and electromagnetic interaction between elementary particles, including, inter alia, the prediction of the weak neutral current"

The Nobel Prize in Physics 1978

Pyotr Leonidovich Kapitsa "for his basic inventions and discoveries in the area of low-temperature physics"

Arno Allan Penzias and Robert Woodrow Wilson "for their discovery of cosmic microwave background radiation"

The Nobel Prize in Physics 1977

Philip Warren Anderson, Sir Nevill Francis Mott and John Hasbrouck Van Vleck "for their fundamental theoretical investigations of the electronic structure of magnetic and disordered systems"

The Nobel Prize in Physics 1976

Burton Richter and Samuel Chao Chung Ting "for their pioneering work in the discovery of a heavy elementary particle of a new kind"

The Nobel Prize in Physics 1975

Aage Niels Bohr, Ben Roy Mottelson and Leo James Rainwater "for the discovery of the connection between collective motion and particle motion in atomic nuclei and the development of the theory of the structure of the atomic nucleus based on this connection"

The Nobel Prize in Physics 1974

Sir Martin Ryle and Antony Hewish "for their pioneering research in radio astrophysics: Ryle for his observations and inventions, in particular of the aperture synthesis technique, and Hewish for his decisive role in the discovery of pulsars"

The Nobel Prize in Physics 1973

Leo Esaki and Ivar Giaever "for their experimental discoveries regarding tunneling phenomena in semiconductors and superconductors, respectively"

Brian David Josephson "for his theoretical predictions of the properties of a supercurrent through a tunnel barrier, in particular those phenomena which are generally known as the Josephson effects"

The Nobel Prize in Physics 1972

John Bardeen, Leon Neil Cooper and John Robert Schrieffer "for their jointly developed theory of superconductivity, usually called the BCS-theory"

The Nobel Prize in Physics 1971

Dennis Gabor "for his invention and development of the holographic method"

The Nobel Prize in Physics 1970

Hannes Olof Gösta Alfvén "for fundamental work and discoveries in magnetohydro-dynamics with fruitful applications in different parts of plasma physics"

Louis Eugène Félix Néel "for fundamental work and discoveries concerning antiferromagnetism and ferrimagnetism which have led to important applications in solid state physics"

The Nobel Prize in Physics 1969

Murray Gell-Mann "for his contributions and discoveries concerning the classification of elementary particles and their interactions"

The Nobel Prize in Physics 1968

Luis Walter Alvarez "for his decisive contributions to elementary particle physics, in particular the discovery of a large number of resonance states, made possible through his development of the technique of using hydrogen bubble chamber and data analysis"

The Nobel Prize in Physics 1967

Hans Albrecht Bethe "for his contributions to the theory of nuclear reactions, especially his discoveries concerning the energy production in stars"

The Nobel Prize in Physics 1966

Alfred Kastler "for the discovery and development of optical methods for studying Hertzian resonances in atoms"

The Nobel Prize in Physics 1965

Sin-Itiro Tomonaga, Julian Schwinger and Richard P. Feynman "for their fundamental work in quantum electrodynamics, with deep-ploughing consequences for the physics of elementary particles"

The Nobel Prize in Physics 1964

Charles Hard Townes, Nicolay Gennadiyevich Basov and Aleksandr Mikhailovich Prokhorov "for fundamental work in the field of quantum electronics, which has led to the construction of oscillators and amplifiers based on the maser-laser principle"

The Nobel Prize in Physics 1963

Eugene Paul Wigner "for his contributions to the theory of the atomic nucleus and the elementary particles, particularly through the discovery and application of fundamental symmetry principles"

Maria Goeppert Mayer and J. Hans D. Jensen "for their discoveries concerning nuclear shell structure"

The Nobel Prize in Physics 1962

Lev Davidovich Landau "for his pioneering theories for condensed matter, especially liquid helium"

The Nobel Prize in Physics 1961

Robert Hofstadter "for his pioneering studies of electron scattering in atomic nuclei and for his thereby achieved discoveries concerning the structure of the nucleons"

Rudolf Ludwig Mössbauer "for his researches concerning the resonance absorption of gamma radiation and his discovery in this connection of the effect which bears his name"

The Nobel Prize in Physics 1960

Donald Arthur Glaser "for the invention of the bubble chamber"

The Nobel Prize in Physics 1959

Emilio Gino Segrè and Owen Chamberlain "for their discovery of the antiproton"

The Nobel Prize in Physics 1958

Pavel Alekseyevich Cherenkov, Il'ja Mikhailovich Frank and Igor Yevgenyevich Tamm "for the discovery and the interpretation of the Cherenkov effect"

The Nobel Prize in Physics 1957

Chen Ning Yang and Tsung-Dao (T.D.) Lee "for their penetrating investigation of the so-called parity laws which has led to important discoveries regarding the elementary particles"

The Nobel Prize in Physics 1956

William Bradford Shockley, John Bardeen and Walter Houser Brattain "for their researches on semiconductors and their discovery of the transistor effect"

The Nobel Prize in Physics 1955

Willis Eugene Lamb "for his discoveries concerning the fine structure of the hydrogen spectrum"

Polykarp Kusch "for his precision determination of the magnetic moment of the electron"

The Nobel Prize in Physics 1954

Max Born "for his fundamental research in quantum mechanics, especially for his statistical interpretation of the wave function"

Walther Bothe "for the coincidence method and his discoveries made therewith"

The Nobel Prize in Physics 1953

Frits Zernike "for his demonstration of the phase contrast method, especially for his invention of the phase contrast microscope"

The Nobel Prize in Physics 1952

Felix Bloch and Edward Mills Purcell "for their development of new methods for nuclear magnetic precision measurements and discoveries in connection therewith"

The Nobel Prize in Physics 1951

Sir John Douglas Cockcroft and Ernest Thomas Sinton Walton "for their pioneer work on the transmutation of atomic nuclei by artificially accelerated atomic particles"

The Nobel Prize in Physics 1950

Cecil Frank Powell "for his development of the photographic method of studying nuclear processes and his discoveries regarding mesons made with this method"

The Nobel Prize in Physics 1949

Hideki Yukawa "for his prediction of the existence of mesons on the basis of theoretical work on nuclear forces"

The Nobel Prize in Physics 1948

Patrick Maynard Stuart Blackett "for his development of the Wilson cloud chamber method, and his discoveries therewith in the fields of nuclear physics and cosmic radiation"

The Nobel Prize in Physics 1947

Sir Edward Victor Appleton "for his investigations of the physics of the upper atmosphere especially for the discovery of the so-called Appleton layer"

The Nobel Prize in Physics 1946

Percy Williams Bridgman "for the invention of an apparatus to produce extremely high pressures, and for the discoveries he made therewith in the field of high pressure physics"

The Nobel Prize in Physics 1945

Wolfgang Pauli "for the discovery of the Exclusion Principle, also called the Pauli Principle"

The Nobel Prize in Physics 1944

Isidor Isaac Rabi "for his resonance method for recording the magnetic properties of atomic nuclei"

The Nobel Prize in Physics 1943

Otto Stern "for his contribution to the development of the molecular ray method and his discovery of the magnetic moment of the proton"

The Nobel Prize in Physics 1942

No Nobel Prize was awarded this year. The prize money was with 1/3 allocated to the Main Fund and with 2/3 to the Special Fund of this prize section.

The Nobel Prize in Physics 1941

No Nobel Prize was awarded this year. The prize money was with 1/3 allocated to the Main Fund and with 2/3 to the Special Fund of this prize section.

The Nobel Prize in Physics 1940

No Nobel Prize was awarded this year. The prize money was with 1/3 allocated to the Main Fund and with 2/3 to the Special Fund of this prize section.

The Nobel Prize in Physics 1939

Ernest Orlando Lawrence "for the invention and development of the cyclotron and for results obtained with it, especially with regard to artificial radioactive elements"

The Nobel Prize in Physics 1938

Enrico Fermi "for his demonstrations of the existence of new radioactive elements produced by neutron irradiation, and for his related discovery of nuclear reactions brought about by slow neutrons"

The Nobel Prize in Physics 1937

Clinton Joseph Davisson and George Paget Thomson "for their experimental discovery of the diffraction of electrons by crystals"

The Nobel Prize in Physics 1936

Victor Franz Hess "for his discovery of cosmic radiation"

Carl David Anderson "for his discovery of the positron"

The Nobel Prize in Physics 1935

James Chadwick "for the discovery of the neutron"

The Nobel Prize in Physics 1934

No Nobel Prize was awarded this year. The prize money was with 1/3 allocated to the Main Fund and with 2/3 to the Special Fund of this prize section.

The Nobel Prize in Physics 1933

Erwin Schrödinger and Paul Adrien Maurice Dirac "for the discovery of new productive forms of atomic theory"

The Nobel Prize in Physics 1932

Werner Karl Heisenberg "for the creation of quantum mechanics, the application of which has, inter alia, led to the discovery of the allotropic forms of hydrogen"

The Nobel Prize in Physics 1931

No Nobel Prize was awarded this year. The prize money was allocated to the Special Fund of this prize section.

The Nobel Prize in Physics 1930

Sir Chandrasekhara Venkata Raman "for his work on the scattering of light and for the discovery of the effect named after him"

The Nobel Prize in Physics 1929

Prince Louis-Victor Pierre Raymond de Broglie "for his discovery of the wave nature of electrons"

The Nobel Prize in Physics 1928

Owen Willans Richardson "for his work on the thermionic phenomenon and especially for the discovery of the law named after him"

The Nobel Prize in Physics 1927

Arthur Holly Compton "for his discovery of the effect named after him"

Charles Thomson Rees Wilson "for his method of making the paths of electrically charged particles visible by condensation of vapour"

The Nobel Prize in Physics 1926

Jean Baptiste Perrin "for his work on the discontinuous structure of matter, and especially for his discovery of sedimentation equilibrium"

The Nobel Prize in Physics 1925

James Franck and Gustav Ludwig Hertz "for their discovery of the laws governing the impact of an electron upon an atom"

The Nobel Prize in Physics 1924

Karl Manne Georg Siegbahn "for his discoveries and research in the field of X-ray spectroscopy"

The Nobel Prize in Physics 1923

Robert Andrews Millikan "for his work on the elementary charge of electricity and on the photoelectric effect"

The Nobel Prize in Physics 1922

Niels Henrik David Bohr "for his services in the investigation of the structure of atoms and of the radiation emanating from them"

The Nobel Prize in Physics 1921

Albert Einstein "for his services to Theoretical Physics, and especially for his discovery of the law of the photoelectric effect"

The Nobel Prize in Physics 1920

Charles Edouard Guillaume "in recognition of the service he has rendered to precision measurements in Physics by his discovery of anomalies in nickel steel alloys"

The Nobel Prize in Physics 1919

Johannes Stark "for his discovery of the Doppler effect in canal rays and the splitting of spectral lines in electric fields"

The Nobel Prize in Physics 1918

Max Karl Ernst Ludwig Planck "in recognition of the services he rendered to the advancement of Physics by his discovery of energy quanta"

The Nobel Prize in Physics 1917

Charles Glover Barkla "for his discovery of the characteristic Röntgen radiation of the elements"

The Nobel Prize in Physics 1916

No Nobel Prize was awarded this year. The prize money was allocated to the Special Fund of this prize section.

The Nobel Prize in Physics 1915

Sir William Henry Bragg and William Lawrence Bragg "for their services in the analysis of crystal structure by means of X-rays"

The Nobel Prize in Physics 1914

Max von Laue "for his discovery of the diffraction of X-rays by crystals"

The Nobel Prize in Physics 1913

Heike Kamerlingh Onnes "for his investigations on the properties of matter at low temperatures which led, inter alia, to the production of liquid helium"

The Nobel Prize in Physics 1912

Nils Gustaf Dalén "for his invention of automatic regulators for use in conjunction with gas accumulators for illuminating lighthouses and buoys"

The Nobel Prize in Physics 1911

Wilhelm Wien "for his discoveries regarding the laws governing the radiation of heat"

The Nobel Prize in Physics 1910

Johannes Diderik van der Waals "for his work on the equation of state for gases and liquids"

The Nobel Prize in Physics 1909

Guglielmo Marconi and Karl Ferdinand Braun "in recognition of their contributions to the development of wireless telegraphy"

The Nobel Prize in Physics 1908

Gabriel Lippmann "for his method of reproducing colours photographically based on the phenomenon of interference"

The Nobel Prize in Physics 1907

Albert Abraham Michelson "for his optical precision instruments and the spectroscopic and metrological investigations carried out with their aid"

The Nobel Prize in Physics 1906

Joseph John Thomson "in recognition of the great merits of his theoretical and experimental investigations on the conduction of electricity by gases"

The Nobel Prize in Physics 1905

Philipp Eduard Anton von Lenard "for his work on cathode rays"

The Nobel Prize in Physics 1904

Lord Rayleigh (John William Strutt) "for his investigations of the densities of the most important gases and for his discovery of argon in connection with these studies"

The Nobel Prize in Physics 1903

Antoine Henri Becquerel "in recognition of the extraordinary services he has rendered by his discovery of spontaneous radioactivity"

Pierre Curie and Marie Curie, née Skłodowska "in recognition of the extraordinary services they have rendered by their joint researches"

on the radiation phenomena discovered by Professor Henri Becquerel"

The Nobel Prize in Physics 1902

Hendrik Antoon Lorentz and Pieter Zeeman "in recognition of the extraordinary service they rendered by their researches into the influence of magnetism upon radiation phenomena"

The Nobel Prize in Physics 1901

Wilhelm Conrad Röntgen "in recognition of the extraordinary services he has rendered by the discovery of the remarkable rays subsequently named after him"

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C V Raman Global University

<https://cgu-odisha.ac.in/>



Inventing the future with learning

Established in accordance with the Odisha Act 01 of 2020, C. V. Raman Global University, Odisha (CGU, Odisha) introduces students to new and innovative ways of learning. It is a vibrant community of students, faculty and staff members committed to making a difference in society by leading with innovation and purpose.

We take pride in our ethos and collaborative culture that foster intellectual engagement and growth. At CGU, Odisha, students learn to challenge the status quo and solve the most difficult problems with analytical rigour and creativity. We continue to add interdisciplinary courses to our existing portfolio to offer a truly global education in the field of science and technology.

Evolution of leadership

CGU, Odisha rests on the legacy and leadership of C.V. Raman College of Engineering (CVRCE) which began its transformative journey in 1997. It grew in record time imparting technical education with a larger purpose and impact through world-class laboratories, research-intensive learning pedagogy, unmatched Centres of Excellence and unhindered connectivity to some of the finest libraries in the world.

CGU, Odisha imbibes the same institutional values of CVRCE and aims to offer a dynamic learning environment to students through its responsive support system, robust infrastructure and global exposure enabled via international seminars, conferences and workshops. Committed to offering quality education to all, it aims to push the frontiers of knowledge with cutting-edge research, innovation and unconventional thinking.

Faculty of Engineering & Technology

Dept. of Chemical Engineering

- B. Tech. in Chemical Engineering
- M. Tech. (Res) in Chemical Engineering
- Ph. D. in Chemical Engineering

Dept. of Civil Engineering

- B. Tech. in Civil Engineering
- M. Tech. (Res) in Civil Engineering
- Ph. D. in Civil Engineering

Dept. of Computer Science & Information Technology

- B. Tech. in Computer Science and Engineering
- B. Tech. in Computer Engineering
- B. Tech. in Computer Science & Information Technology
- B. Tech. in Computer Science (System Engineering/Cloud Computing)
- B. Tech. in Computer Engineering (Software Engineering)
- B. Tech. in Computer Science & Engineering (AI & Machine Learning)
- B. Tech. in Computer Science & Engineering (Data Science/Web Technology)
- B. Tech. in Computer Science & Engineering (IoT& Cyber Security including Block Chain Technology/Robotics & Artificial Intelligence)
- B. Tech. in Artificial Intelligence and Data Science
- BCA (Bachelors in Computer application)
- M.Tech. in Computer Sc. and Engineering
- M. Tech. (Res) in Computer Science & Engineering

- Ph. D. in Computer Sc. & Engineering

Dept. of Electrical Engineering.

- B. Tech. in Electrical Engineering
- B. Tech. in Electrical & Electronics Engineering
- M.Tech. in Electrical Engineering
- M. Tech. (Res) in Electrical Engineering
- Ph. D. in Electrical Engineering

Dept. of Electronics & Communication Engineering

- B. Tech. in Electronics & Communication Engineering.
- M.Tech. in Electronics & Communication Engineering.(Signal Processing & Communication)
- M. Tech. (Res) in Electronics & Communication Engineering
- Ph. D. in Electronics & Comm. Engg.

Dept. of Marine Engineering.

- B. Tech. in Marine Engineering.
- STCW Courses
- Ph. D. in Marine Engineering

Dept. of Mechanical Engineering.

- B. Tech. in Mechanical Engineering.
- M.Tech in Heat Power Engineering
- M.Tech. in Mechatronics
- M. Tech. (Res) in Mechanical Engineering
- Ph. D. in Mechanical Engineering

Hotel Management

- B.Sc. in Hospitality & Hotel Administration
- P.G. Diploma in Accommodation Operation & Management
- Diploma in Food-Production
- Diploma in Food & Beverage Service
- Diploma in Front - Office Operation
- Diploma in House-Keeping
- Hunar Se Rozgar Tak

Diploma

- Civil Engineering
- Computer Science & Engineering
- Electrical Engineering
- Electronics & Telecom. Engineering

- Mechanical Engineering
- Mechatronics Engineering

Dept. of Agriculture Science

- B.Sc. in Agriculture

Faculty of Physical and Mathematical Sciences

Dept. of Chemistry

- M. Sc. in Chemistry
- Ph. D. in Chemistry

Dept. of Mathematics

- M. Sc. in Applied Mathematics & Computing
- Ph. D. in Mathematics

Dept. of Physics

- M. Sc. in Physics
- Ph. D. in Physics

Faculty of Management and Law

Dept. of MBA

- Bachelor in Business Administration (BBA)
- Master in Business Administration (MBA)
- PhD. in Business Management

Faculty of Humanities and Social Science

Department of Humanities

- M.A. in English
- Ph.D. in English

Ranking & Accreditation

National Ranking

CGU, Odisha has been ranked as one of the top 100 Engineering

Institutions in India as per the National Institute Ranking Framework (NIRF), MHRD, Govt. of India in 2016, 2017, 2018, 2019, 2020 & 2021

Accreditation

Awarded 'A' Grade by the National Assessment and Accreditation Council (NAAC)

Accredited by the National Board of Accreditation (NBA) for 06 UG courses

Recognition

Recognised as a Scientific and Industrial Research Organization (SIRO) by DSIR, the Government of India

Partnership

Partner institute of 'Study in India' - an initiative by the Ministry of HRD, Government of India for the admission cycle 2020-2021

CAMPUS LIFE

C.V.Raman College of Engg. with its beautifully landscaped and carefully tended gardens, provides an ideal environment for a congenial learning experience. Here is a campus that invites students out of their hostels to spend time after classes, amidst greenery and floral colour. The Institute provides separate accommodation for boys and girls. Students seeking admission into CVRCE have to apply for accommodation arrangements at the time of admission.

Dr C V Raman

University

<https://www.cvrn.ac.in/>

Dr. C.V. Raman University was set up as Chhattisgarh's first private university on 3rd November 2006 and inaugurated on 14th October 2007, over a vast area of 55 acres with excellent infrastructure in the tribal region of **Kota, District Bilaspur in Chhattisgarh**. The university was established under Niji Vishwavidyalaya Adhiniyam 2005. Over the years, the university has established itself as the research and educational hub of the region, covering a wide expanse of courses and fields like engineering, management, arts, science, education, law, IT, etc. The university started functioning as per its approved status and ordinances from the academic year (2007-08). It is recognized by UGC and approved by AICTE, NCTE, BCI as well as certified by ISO:9001:2008, a member of AIU, accredited with B+ grade by NAAC, listed in NIRF ranking. It is listed in Top 30 Engineering Colleges in India.

Vision

Dr. C. V. Raman University will have a transformative impact on society through continual innovation in education, research, creativity and entrepreneurship incorporating social, ethical, human and spiritual values.

Mission

- ❖ To create transformative educational experience for students focused on deep disciplinary knowledge problem solving, leadership, communication and interpersonal skill, and personal health and wellbeing.
- ❖ Creating a collaborative environment open to the free exchange of ideas, where research, creativity, innovation and entrepreneurship can flourish.
- ❖ Ensuring individuals can achieve their full potential.

- ❖ To impact society in a transformative – regionally, nationally and globally by engaging with partners outside the traditional border of the University campus.

Values

- ✓ Dedication, reflected in our distinctive work ethic and in our commitment to excellence.
- ✓ Impact, reflected in our commitment to address critical issues facing society regionally, nationally and globally.
- ✓ Collaboration, reflected in our interdisciplinary approach, our focus on internal and external partnership and our capacity to create new fields of inquiry.
- ✓ Creativity, reflected in our openness to new ideas and forms of expression, intellectual curiosity, willingness to take risks and entrepreneurial spirit.
- ✓ Empathy and compassion, reflected in our focus on improving the human condition and on the personal development of the members of our community.
- ✓ Inclusion, reflected in a culture and climate that seeks, welcomes and advances talented minds from diverse background.
- ✓ Integrity, reflected in our adherence to the highest ethical standards in personal and professional behaviour and in our commitment to transparency and accountability in governance and everything we do.
- ✓ Sustainability, reflected in our shared commitment to lead by example in preserving and protecting our natural resources and in our approach to responsible financial planning

FACULTY OF SCIENCE

For any country in this world, the state of its education serves as a driving force for its economic growth. A nation with good educational institutions equipped with the right infrastructure for research facilities and science programs can only produce a knowledgeable and efficient workforce to drive its economy on new heights. Understanding the need for science education and its importance in nation building CVRU established the Department of Science to offer range of graduation as well as post-graduation programs.

CVRU Department of Science provides modern infrastructure and outstanding facilities for innovative research programs and vocational courses. The conducive environment provided to students to study and excel in this competitive era is incomparable with any science college of Chhattisgarh and that is why CVRU Bilaspur has been ranked as the best science college in Chhattisgarh.

The esteemed faculty of the Department of Science aims at infusing analytical thought process for a better understanding of technical aspects of the curriculum using modern and traditional teaching practices. This serves as a launching pad for students to use their learning in practice.

Being the best science college in Bilaspur, CVRU Department of Science uses social learning tools like e-learning aids, conducts the workshop and industry visits to give practical exposure to the students about innovative ideas and technology. The relentless efforts in the field of science made by CVRU Bilaspur have opened new avenues to graduates to get the best jobs with good remuneration.

CVRU Bilaspur is aims to make students eligible for research-oriented programs, post-graduation courses and even doing jobs in MNCs right after their graduation. The Faculty of Science has four departments: Physics, Chemistry, Mathematics and Life Science.

FACULTY OF ENGINEERING

The present era is all about fast-changing technology used in every industry right from agriculture, manufacturing units, IT, telecom to artificial intelligence. A nation can progress only if it has good infrastructure to develop and use new-age technology. Technology-driven industries can change the state of a country to either stand as a developing or developed country. The overall economy of a country is boosted by using fast pace technology and this is not possible without a team of competent engineers. Understanding this most important element of nation-building drive, CVRU Department of Engineering aims for providing good infrastructure and facilities to train engineers with the latest industrial skills and research orientation mindsets. CVRU Bilaspur has always acted as an incubator for one of the finest engineering professionals in the country and there it is ranked as one of the top engineering colleges of India.

The CVRU department of engineering is recognized as one of the top engineering colleges in Chhattisgarh for providing a robust infrastructure for various research programs. The esteemed faculty uses traditional teaching methods like classroom lectures, course assignment along with new-age teaching practices like practical tutorials, conferences, industrial training to impart theoretical as well as practical knowledge of engineering. The students also get good exposure to work with proficiency in their respective fields to beat all the challenges of professional life. One of the top colleges of engineer in Chhattisgarh, CVRU Bilaspur has five dependents: Mechanical Engineering, Civil Engineering, Electronics and Communication Engineering, Computer Science Engineering and Electrical Engineering.

FACULTY OF LAW

The Institute of Law Dr.C.V. Raman University, Kargi Road Kota, and Bilaspur (C.G.) was established in 2011 with the objective to provide qualitative legal education. The Institute offers LL.B., B.A.LL.B., and B.Com. LL.B. LL.M. and Ph.D. degree in Law. Institute has excellent facilities of Research in Law and presently more than a dozen scholars have been enrolled in Ph.D. Degree.

Institute is having well equipped furnished spacious building with large number of classrooms, lecture halls, Moot Court, Legal Aid Clinic, smart classroom and a well-

equipped library. The Institute is imparting Legal Education using modern techniques. It cultivates and infiltrates legal aptitude of the students aiming to make them excellent advocates and resources, who would act as champions for law and justice. The Institute is conducting legal literacy camps, moot court competitions and other activities helpful to inculcate legal aptitude in the students.

The faculty members of Institute work more as guide and counsellors creating an environment of personal relationship and contribute to the growth and personality of the students. The Institute has fully equipped library other than Central Library of the University. The library of the Institute has sufficient books, journals, periodicals and other literature. In the Institute well equipped Computer Lab with Legal software, are present.

The students of the Institute exhibit praiseworthy performance in various all India moot court competitions. The Institute undertakes the placement of students through campus interviews. The Institute encourages its students to organize and participate in co-curricular activities moot court and moot performance on burning socio-legal problems, human rights etc.

FACULTY OF ARTS

An arts education is perfect for someone who does not wish to go in for technical subjects. It has always been an option for people who are creative and are interested in language, philosophy, history and the wide range of subjects that an education in arts can offer.

Being one of the best arts colleges in India, CVRU Bilaspur hopes to establish strong standards for an education in arts for students who are interested in arts, literature, philosophy and a wide range of subjects.

The faculty at CVRU Bilaspur consists of some of the most experienced people in the industry and aims to improve creativity, communication skills, increase awareness on social issues and reforms, give the students the ability to practice critical thinking and create some of the best professionals in the fields of social work, public and administrative services and in the artistic fields.

CVRU Bilaspur is rated as one of the best arts colleges in India and offers some of the most popular undergraduate and postgraduate courses in the arts stream and humanities courses.

FACULTY OF COMMERCE & MANAGEMENT

Established with the aim to expand the envelope of knowledge and innovation in commerce education, CVRU's Department of Commerce has emerged as a leading Commerce College in Chhattisgarh. With our under graduate and postgraduate programmes, the department is laying the foundation, a prerequisite, for a raft of vocational careers, including planning, finance, marketing, accountancy, banking and brokering, and tax practitioners, on top of academics and higher research.

In a brief time, we have successfully redefined the commerce education in the state,

bringing the dividends of quality education to the hinterland of central India. The department, with its world-class infrastructure and curriculum, is on the verge of becoming attaching and research, along with curriculum development, centre in the discipline of Commerce.

The rapid growth of the department is reflected among its students who have acquired knowledge, skills, as well as attitudes, for the successful career in the industry and research. We upend the conventional classroom education with the help of modern aids, including computer-aided visuals, conferences, industry exposure, internships and projects.

Our innovative approach and constantly evolving syllabus and curriculum in the commerce education have distinguished us from the commerce colleges in Chhattisgarh, while reinforcing its place as a centre of excellence.

Management of assets plays a huge role in leveraging the full potential of a company; without efficient management professionals with effective strategies, its business model cannot be stable or sustainable. Recognising the importance of management professionals in an economy, we, at our MBA colleges in Bilaspur, Chhattisgarh, provide an environment that assists young minds to evolve into business graduates who understand how to innovate and manage the resources in an organisation.

Our pedagogical methodology, which makes one of the top MBA colleges in Chhattisgarh, seeks to impart leadership skills and enhance interpersonal communication skills, along with conventional quantitative and analytical skills.

To achieve what we aspire, a group of qualified and experienced educationists are selected from across the nation, which has helped us to produce management graduates who, with complementing abilities to fill the demand of managers, are managing organisations or helping in smooth functioning of a company.

The programmes, one of the most comprehensive MBA courses in Chhattisgarh, polish individuals to achieve the respective potential, and let acquire the necessary financial analysis proficiency, international relationships, and decision-making skills. Equipped with the best infrastructure and distinguished faculty members, we have established ourselves as a centre of management studies, where students are carved for the upcoming challenges.

FACULTY OF EDUCATION AND PHYSICAL EDUCATION

Education is the key to success. To achieve new heights in this competitive world, education is the only key which acts as a foundation for everything. Education plays a crucial role in one's life. It helps in understanding the values towards life, to enhance ourselves as a human being and also to add new dimensions. It is said that, the knowledge that we have will only get its importance if we transfer it to someone who is devoid of it and also develop our inner qualities. Faculty has two departments: Education and Physical Education.



DR. C.V. RAMAN UNIVERSITY

Chhattisgarh, Bilaspur AN AICTE GROUP UNIVERSITY

Approved by : AICTE | NCTE | BCI | ARU | Joint Committee : UGC | DEB | AICTE | Recognized by : UGC | A NAAC Accredited University



A UNIT OF
AICTE
GROUP OF UNIVERSITIES

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and affordable higher education



**BE THE
CHANGE**



ADMISSION HELPLINE 6261-900581, 6261-900582

Add: Kargi Road, Kota, Bilaspur (C.G.) Ph. 07753-253801, Email: admissions@cvru.ac.in, info@cvru.ac.in
City Office: Dr. C.V. Raman University, Infront of Pallav Bhavan, Ring Road No.2, Bilaspur (C.G.) Ph. 07752-270388

FACULTIES

ENGINEERING & TECHNOLOGY
 SCIENCE | PHARMACY | LAW | ARTS
 COMMERCE & MANAGEMENT
 EDUCATION & PHYSICAL EDUCATION
 INFORMATION TECHNOLOGY
 JOURNALISM & MASS COMMUNICATION




FACULTIES

- ◆ ENGINEERING & TECHNOLOGY
- ◆ SCIENCE ◆ PHARMACY ◆ LAW ◆ ARTS
- ◆ COMMERCE & MANAGEMENT
- ◆ EDUCATION & PHYSICAL EDUCATION
- ◆ INFORMATION TECHNOLOGY



16
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Dr CV Raman University

<https://www.cvrubihar.ac.in/>

Dr. C.V. Raman University has been established in the year 2018 located in Bhagwanpur, Vaishali, Bihar. It is one of the best private universities in India and first private university in the state of north Bihar, which is dedicated to achieve excellence in education and research in multi disciplines with its aim to develop the technical as well as professional skills of students.

The university has its own building having professionally designed with modern technique having its different department located in various areas. The developed infrastructure having 80 modern classrooms with facility for conducting smart classes with a seating capacity of approximately 1600 students of various disciplines. The university has its developed computer lab to impart training facilities for providing separate computer to approximately one thousand students at a time.

It first instance the university has started the following five faculties, they are:-

- Faculty of Commerce and Managements:-B. Com(Hons),BBA, M. Com, MBA.
- Faculty of Arts & Humanities: - BA (Hons), MA , B.Lib, M.Lib, MSW
- Faculty of Science:- B.Sc. (Hons) M. Sc. (Hons)
- Faculty of Computer Science & IT:- DCA, BCA, B. Sc.(IT) PGDCA, M.Sc.(IT)
- Faculty of Agriculture:- B.Sc. (Ag)

In addition to it the university has its own separate Physics Lab, Chemistry Lab, Electrical Engg. Lab, Machine shop Lab, Civil Engg. Lab, Soil testing lab, boiler as well as Refrigeration and Air Conditioning Lab, Hydrolics and instrumetation Lab, Electronic Engg. Lab etc. is located in different parts of the university campus.

It has well equipped e-Library as well as dell net software and having more than Ten Thousand books in various subjects. The library has various numbers of National International Journals magazines, News Papers etc.

The university has highly qualified and experienced faculties attaining requisite and desirable qualifications to meet all the parameters as decided by university grant commission and Various regulatory Bodies.

The teachers are dedicated to provide the best education to teach every student taking in to account the students having difficulties in the main class they are being covered during tutorial classes.

The university has its own modern cafeteria located in the campus which is managed to provide good quality of breakfast / Lunch for students having sufficient seating capacity for the students in the canteen.

It is ragging free and healthy campus and multi-disciplinary approach is being adopted to maintain peaceful and educational atmosphere in the entire campus. The university has its own modern transportation facility consisting of latest model buses. Which are plying in various routes of Vaishali, Muzaffarpur, and Patna District as well as touching Samastipur District.

Awards:

- ASSOCHAM INDIA Excellence in Education, Training & Development Award 2018.
- Felicitated in 2014 for the Pioneering Initiative of Accepting NIELIT Qualifiers for Higher Courses.
- World Education Award 2016 (Dubai) for Progressive Higher Education Institutions Operating in Private Space
- ASSOCHAM Excellence in Education Award 2014
- World Education Award 2015
- Shiksha Ratna Award 2012

Faculties:

FACULTY ENGINEERING TECHNOLOGY

The campus at C.V Raman University, Bihar is designed by professionals, which means that the infrastructure is state of the art. The university has facilities like a hostel and cafeteria for all the students. The cafeteria serves nutritious food at mealtime. Apart from these facilities, the university also has a recreational centre and a sports complex, for students who want to take part in extracurricular activities.

The faculty members at the university are very experienced and qualified, and they can deal with every challenge they face in the classroom. This includes having the ability to teach students who have different learning styles. Since students from all types of different backgrounds enroll into the university, it is very important for the faculty to be able to cater to those different needs.

The professors use a variety of teaching methods, like classroom lectures and presentations. More modern approaches like smart classes and e-learning are used as well. The curriculum also includes events like workshops and guest lectures. These guest lectures give students the opportunity to interact with professionals who have worked in the same field for a long time.

FACULTY OF AGRICULTURE

Agriculture is an extremely important part of the Indian economy. Over 50% of the population of India is working in agriculture-related sectors. Agriculture contributes to at least 25% of the GDP or gross domestic product of India.

The agriculture course stands for everything related to harvesting and husbandry, including cultivating plants for food, medicine and biofuel and other resources necessary for human sustenance.

Bachelor of Science in agriculture is an undergraduate course that focuses on gaining theoretical knowledge as well as learning about the latest developments taking place in the agriculture sector. But not many students opt for this course. Dr. C.V Raman University recognizes the importance of agriculture, which is why a fully functional agricultural department has been established in CVRU Bihar, and it is considered as one of the best agriculture colleges in Bihar.

CVRU Bihar aspires to raise awareness about agriculture as a course so that students take an interest in this field. With more students opting to study agriculture, the gap can be bridged and challenges can be resolved.

FACULTY OF ARTS

CVRU Bihar is built on a lavish campus with state-of-the-art infrastructure having e-learning facilities, a massive library, sports complex, and a recreational centre to practice various art forms. Apart from these the university also has a cafeteria, medical

room, and transport facility for the students to offer the best college life and quality education.

The esteemed faculty of CVRU is highly qualified and experienced. They are committed to impart in-depth subject knowledge and instil essential skills like creativity, communication skills, and critical thinking, to craft young minds for the artistic field, media, NGO, public & administrative services sector, etc.

Apart from all these CVRU Bihar also runs the Chancellor Scholarship program to provide financial help to meritorious and underprivileged students. The university also has a training and placement cell to prepare students for job interviews by grooming their personalities and providing professional skill training for their bright future.

FACULTY HUMANITIES

CVRU Bihar is built on a lavish campus with state-of-the-art infrastructure having e-learning facilities, a massive library, sports complex, and a recreational centre to practice various art forms. Apart from these the university also has a cafeteria, medical room, and transport facility for the students to offer the best college life and quality education. The esteemed faculty of CVRU is highly qualified and experienced. They are committed to impart in-depth subject knowledge and instil essential skills like creativity, communication skills, and critical thinking, to craft young minds for the artistic field, media, NGO, public & administrative services sector, etc.

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FACULTY OF COMMERCE

The faculty of commerce at CVRU Bihar has modern infrastructure, outstanding educational facilities, highly qualified faculties and placement cell. The university has highly experienced and well-qualified faculty members who are committed to impart thorough knowledge of commerce subjects and build professional skills like communication, problem-solving, decision making, leadership qualities, and critical thinking in students. Apart from giving academic knowledge the faculty members are also part of various research & educational initiatives to participate in seminars organised by the best commerce colleges in India to bring the latest knowledge for the students.

CVRU Bihar also has strong ties with leading industries and MNCs to assist students in pursuing internship programs and campus placement. The university also conducts guest lectures, conferences, and seminars for students where they get the opportunity to interact with top managers of the corporate and learn the real challenges of the professional world. This makes the learning process exciting, enriching, and engaging. CVRU Bihar also gives emphasis on the overall development of the student. For this, the university encourages students to participate in extracurricular activities and sports competitions to develop the right attitude in life.

Right to education is the constitutional right in India and for this CVRU Bihar provides the Chancellor Scholarship to the meritorious and underprivileged students so that they can fulfil their dreams of pursuing higher education with financial aid.

FACULTY OF INFORMATION TECHNOLOGY

Computer science is one of the few fields that are changing every day, as there are so many new developments taking place in this field. This is one of the reasons why it is good to opt for BCA or Bachelor in Computer Applications as a course. Since there are so many new advancements in computer science, there is no shortage of jobs in this field. Students can find employment immediately after completing the course. This is one of the few undergraduate courses that offer this surety.

FACULTY OF MANAGEMENT

The campus infrastructure at CVRU Bihar has been designed by professionals and is well equipped with everything a student needs for a successful educational experience. The university has facilities like a sports complex and a recreational center for students who wish to engage in extracurricular activities. Apart from these facilities, there is a hostel and cafeteria for students who enrol into the university and are not from Bihar. The cafeteria serves nutritious meals at all times of the day. The faculty at the university is very experienced and qualified. This makes sure that they are capable of teaching students from all kinds of backgrounds. This helps students learn to the best of their capabilities. In the duration of the course, students are taught about the different practices of management using classroom lectures and practical work in the form of internships and project work. Students are also taught to hone their communication skills and leadership skills as these are skills that are necessary for working in any field, especially in management.

FACULTY OF SCIENCE

The Oxford Learners Dictionary defines Science as “knowledge about the structure and behavior of the natural and physical world, based on facts that you can prove, for example by experiments.” Over time Science has evolved into multiple streams and sub-streams and yet the basic premise of all scientific studies remains the same – experiment and empirical evidence.

Today education in science is a basic requirement for most jobs and professions and the knowledge of STEM (Science, Technology, Engineering, and Mathematics) hasn't been so important ever before. A good science college must not only give a strong theoretical base to its students but should also equally encourage experimentation and practical application of the learnings. With this noble intention, CVRU Bihar has opened its science college which is now one of the top BSc colleges in India.



Dr CV Raman University

<http://www.cvrump.ac.in/>

Dr. C.V. Raman University (Khandwa) is the fifth university under the AISECT Group of Universities and is located in the Nimar region of Madhya Pradesh (Khandwa). CVRU Khandwa has the exceptional infrastructure, highly skilled teachers and experienced trainers with a good industrial background to provide the precise knowledge and skill to the students. Dr. C.V. Raman University (Khandwa) has AISECT-NSDC partnership and certification along with an online placement support by Rojgar Mantra.

ACADEMICS

School Of Agriculture

Growth in agriculture propels the economic development of the country. Majority of our population directly or indirectly depends on agriculture, which is why agriculture tops the priority in higher education. The comfortable food grain situation that the country enjoys, is the result of skilled human resource developed, technological capabilities created for HRD, development of technology and their dissemination to the highly receptive farming community. The need of the hour therefore, is to develop the human resources through an effective agricultural education system with emphasis on skill, which will be primarily responsible for green, white, yellow and blue revolutions, signifying respective increase in food grain, milk, oilseed and fish production. The Faculty of Agriculture in Dr. C.V. Raman University has introduced UG level course which promises good prospectus for not only an excellent career but also to ensure excellent job opportunity. The course in B.Sc. Hons. (Ag.) provides hands-on training in farming, food processing, horticulture, animal husbandry production

and various other related fields which will transform a student into a complete professional.

School of Computer Science and Information Technology

The Indian IT Industry has grown at an average annual rate of 30% over the past decade. The development of technology is changing the way we live, even though the basic scientific and engineering principles on which IT is based have not changed. These principles form the core of our skill-based programmes and provide the essential body of knowledge to which graduates can add their insight, imagination and ability to develop information systems for the future.

University also has the following Schools:

Arts and Humanities, Commerce, Management, Paramedical Science and Science offering Diploma, Undergraduate and Postgraduates courses.

IMPECCABLE PLACEMENTS

AISECT, a 35-year-old organization, has over the years earned the reputation of being a reliable trainer and supplier of best skilled professionals to the industry. The reputation has helped AISECT to develop a close association with most of the top management and IT companies, giving the students an option to choose from a plethora of companies for their summer training and on-campus placement. The University helps shape the future of the students by providing them placement opportunities once they complete their education. Its association with country's leading organizations helps to provide training programmes to students which enable them to become industry-ready.





Pictures

Dr CV Raman



Chandrasckhara Iyer and Family. Raman extreme left



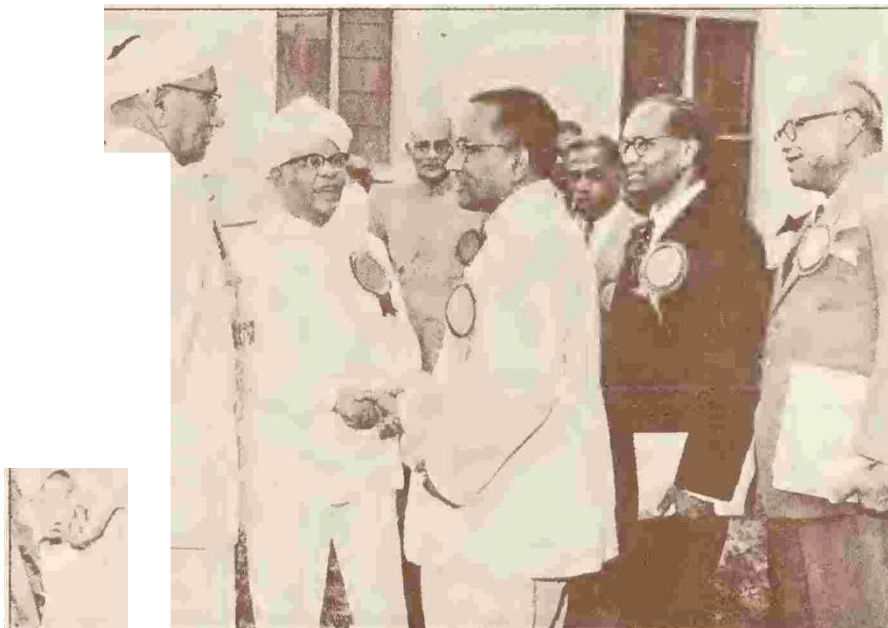
Some students of Presidency College. Raman standing right



Lokasundari, Mrs CS Ayyar, Mrs KV Iyer



Science College, Calcutta



Academy meeting at Annamalainagar



The banquet after the Nobel ceremony.
Raman with turban centre at extreme right
row



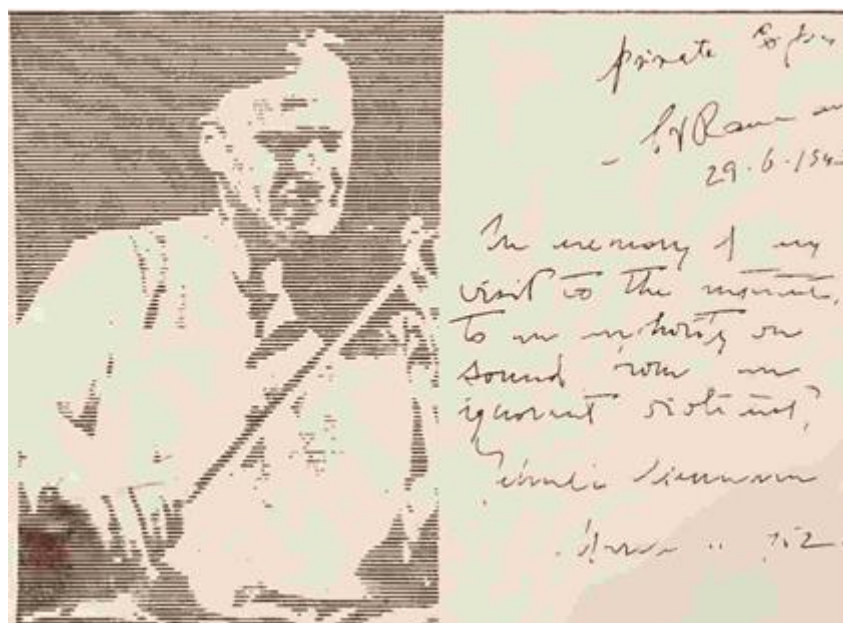
Raman visiting a Laboratory



Raman in traditional Indian dress



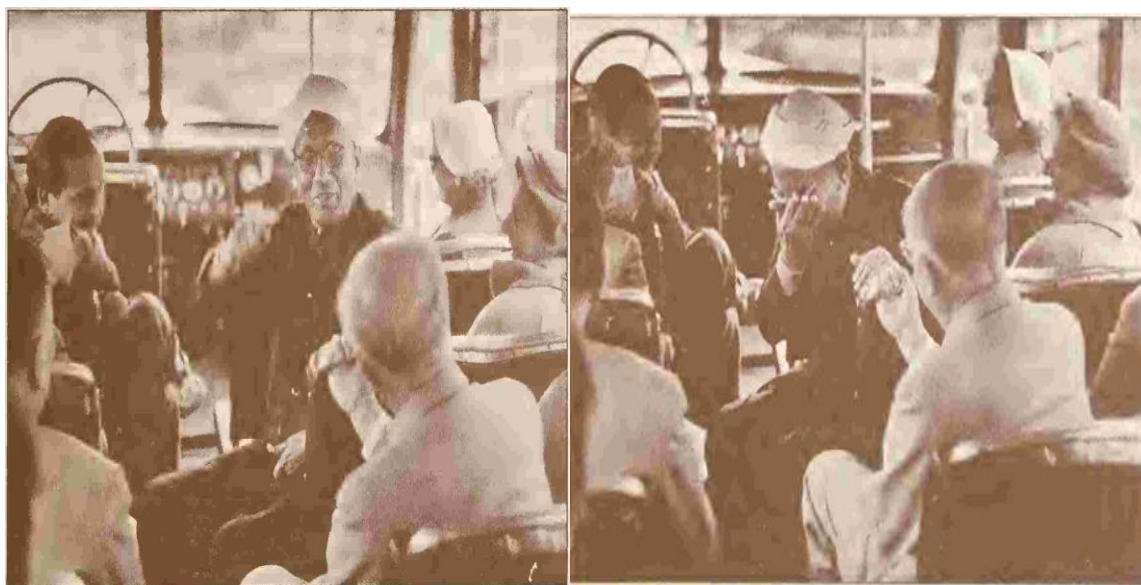
Mahatma Gandhi visiting Raman at IISc



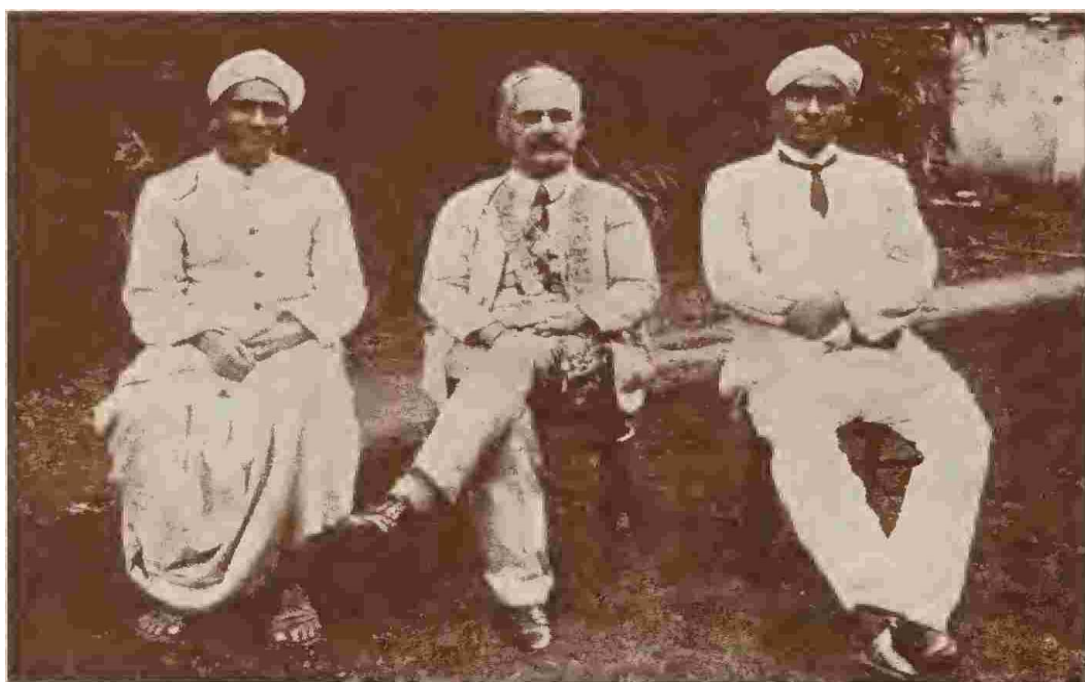
Yehudi Menuhin's inscription in Raman's monograph on the violin



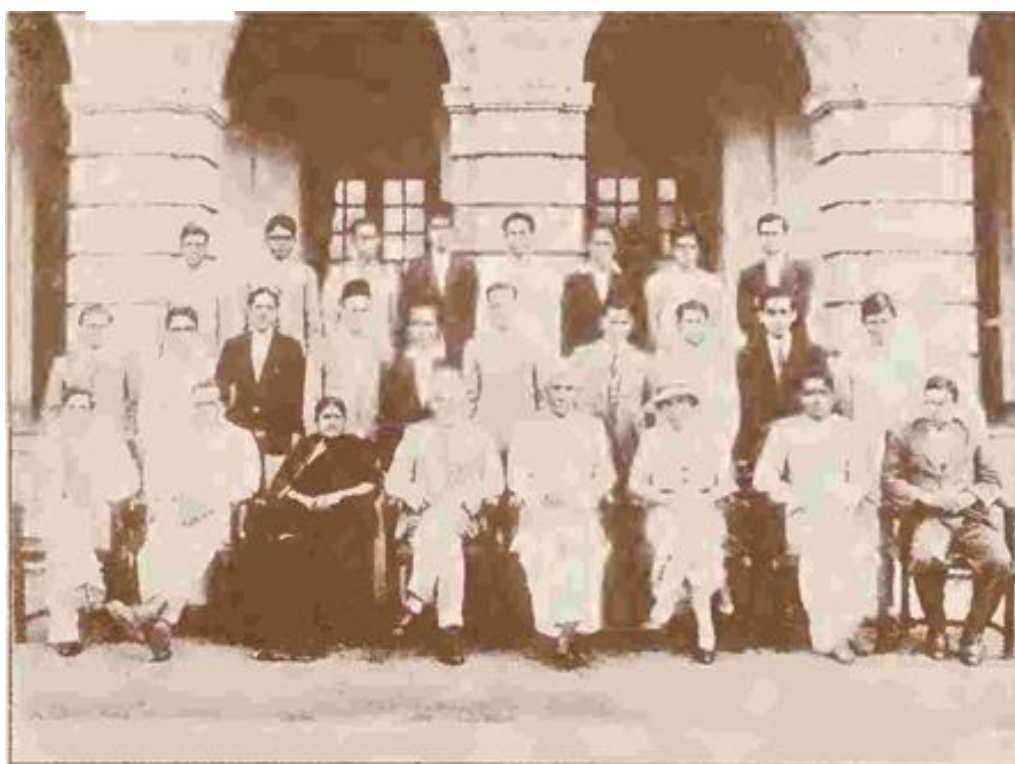
Niels Bohr and CV Raman



Raman with scientists in a Tourist bus



KS Krishnan, Sommerfeld & CV Raman



The Ramans and Borns with students of IISc



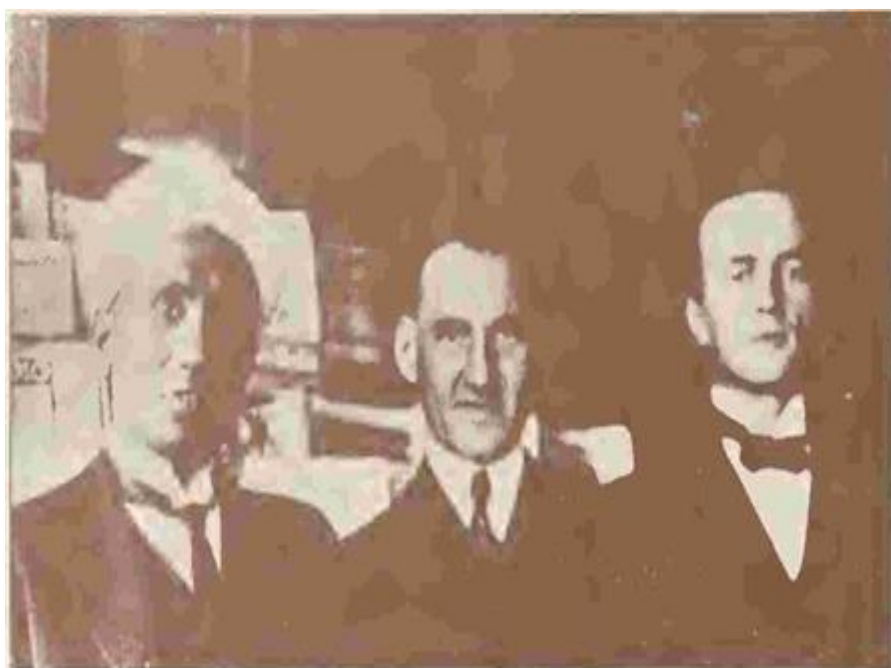
A discussion on board a ship



Krishnaraja Wodeyar, the Maharaja of Mysore, a patron of arts and science,
who gifted the land for the Raman Institute



At the Niels Bohr Institute, Copenhagen



Raman and AH Compton (centre)



KS Krishnan



Raman and Heisenberg (right)



Raman examining flowers



Raman and S Chandrasekhar.
Lalitha Chandrasekhar is partly seen



The pond in his ancestral village Purasakkudi



A lane in ancestral village



Ancestral House of Raman's family - Purasakkudi



House in Thiruvanaikkaval, where Raman was born.



Raman's Horoscope in Tamil-1888.
Raman had no belief in horoscope.



Room in which Raman was born.



Tiruchirapalli : Rockfort Temple and tank.



R. Chandrasekhar Iyer (Father) Parvathi Ammal (Mother)



Gnanambal (Raman's Aunt)

BROTHERS & SISTERS



Subramanyan
(1886-1959)



Mangalam
(1891 - 1914)



C Ramaswamy
(1907 -)



VENKATARMAN
(1888 – 1970)



Kumaraswamy
(1894 - 1914)



Sitalaxmi
(1901 - 1971]



Meenakshi
(1903 - 1912)



Sundaram
(1898 - 1907)

Certificate from the Principal, A. V. N. COLLEGE, VIZAGAPATAM,

1st Dec 1905

Uma R

Uris

cent B

a student of the Mrs. A. V. N. College from 1894 to 1902. He is one of our most distinguished students, of remarkable talents & unimpeachable conduct.

D. D. Srinivasan

Principal

Letter to young Raman from his father consulting him on the teaching of mechanics to his students.

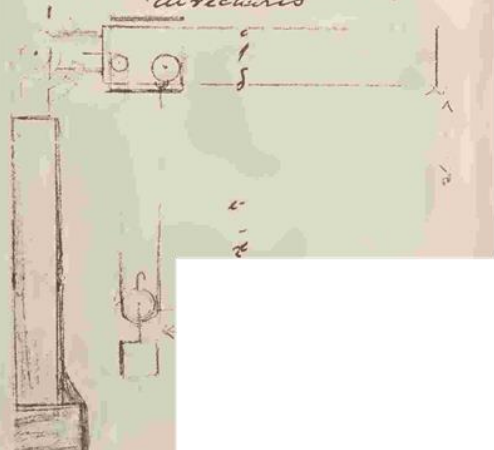
Certificate from Principal Mrs. A. V. N. College

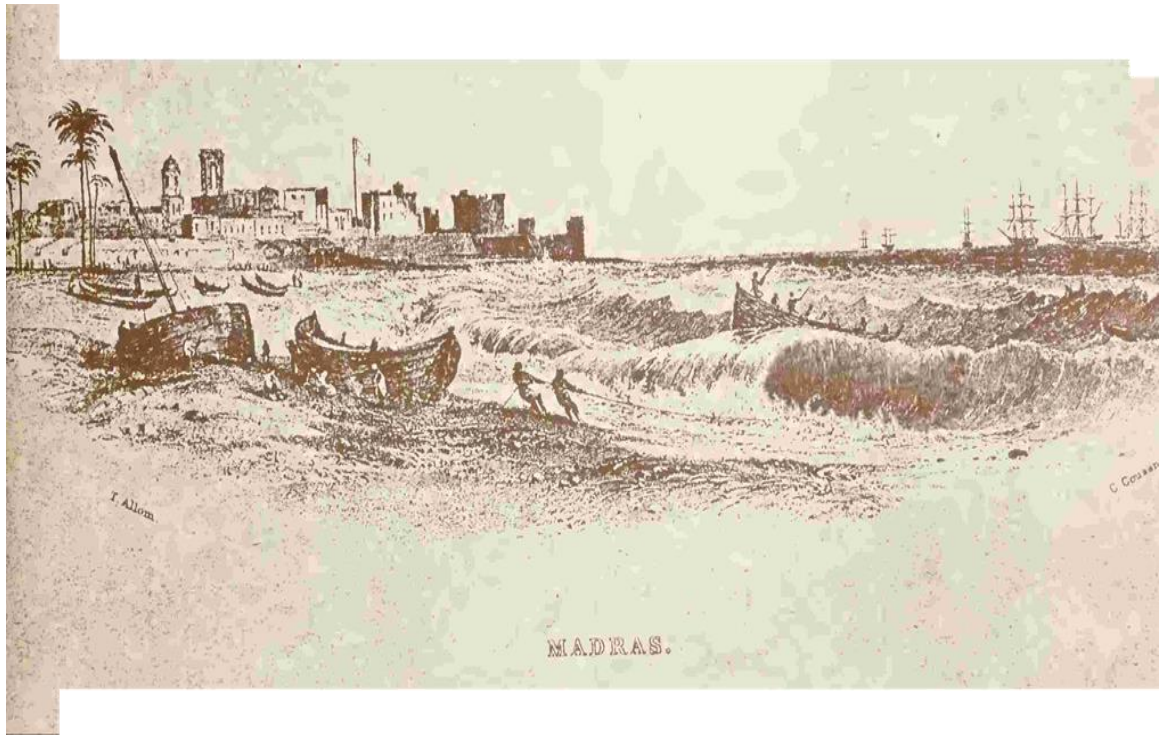
Letter to young Raman from his father consulting him on the teaching of mechanics to his students.

what do you think of it? Can you suggest anything towards its improvement. It will serve the purpose of giving to young minds a rough idea of the magnitude and the direction of the displacement equivalent to two given displacements in given directions.

I have not yet begun to attack the problem of Indian scales. But from the little I have heard of what Helmholtz has to say on Indian scales I feel

Here is the form which I should like to give to the mechanical contrivance for illustrating "Compounding of displacements in any given ratio" and also in any two directions

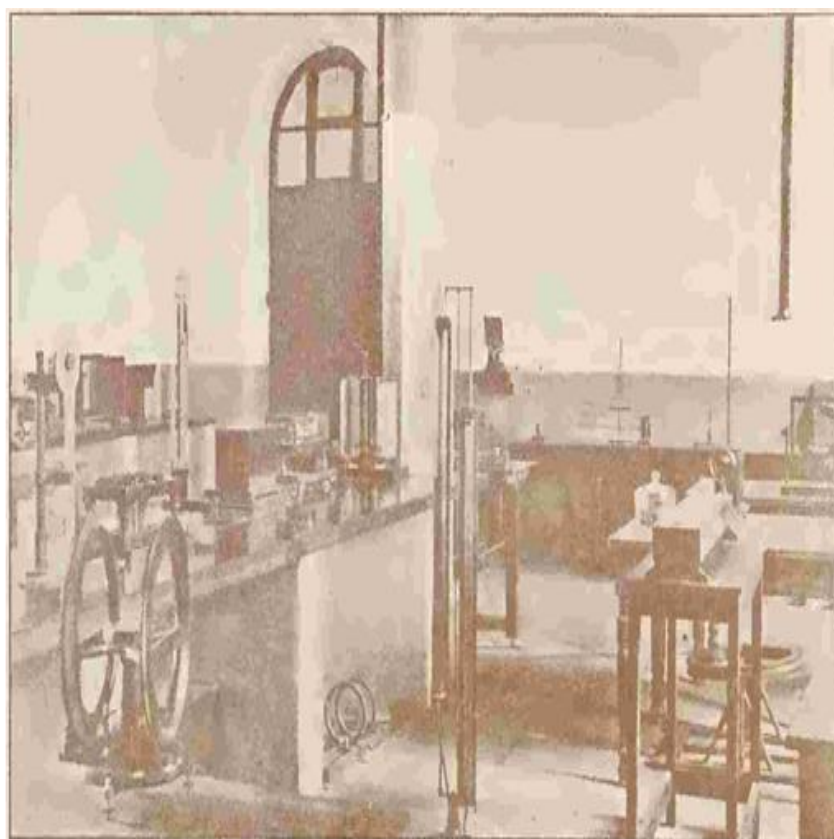




Madras Marine Beach



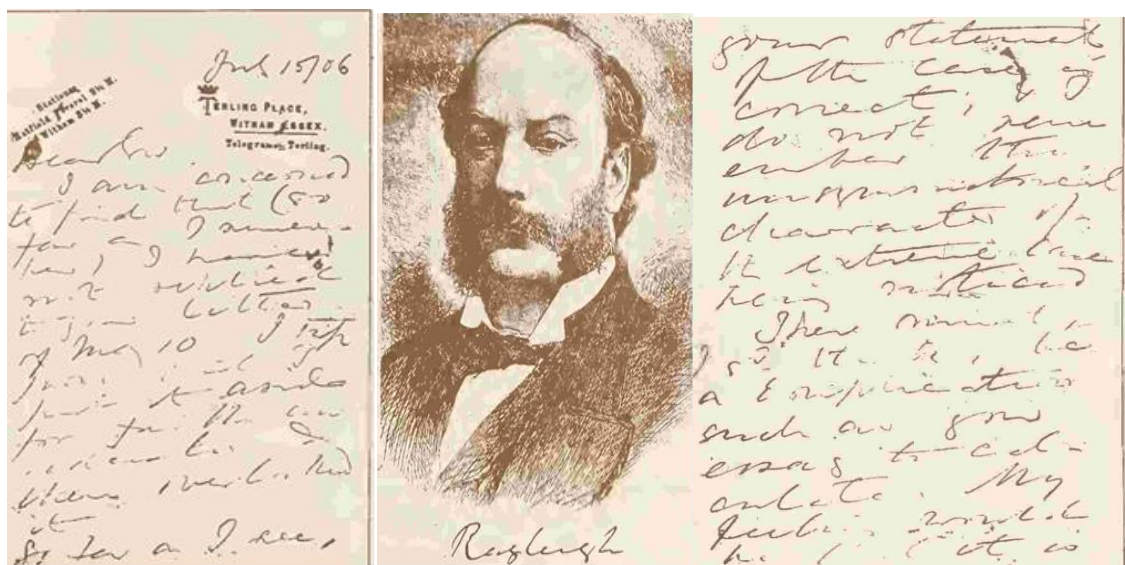
The Presidency College, Madras



The Physics Laboratory, Presidency College



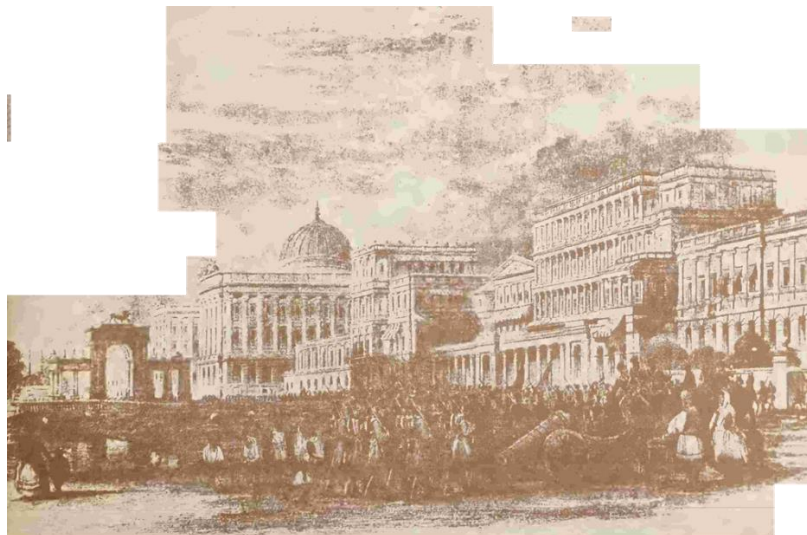
Presidency College : The Group Photograph



Letter from Lord Rayleigh to Raman (1906)



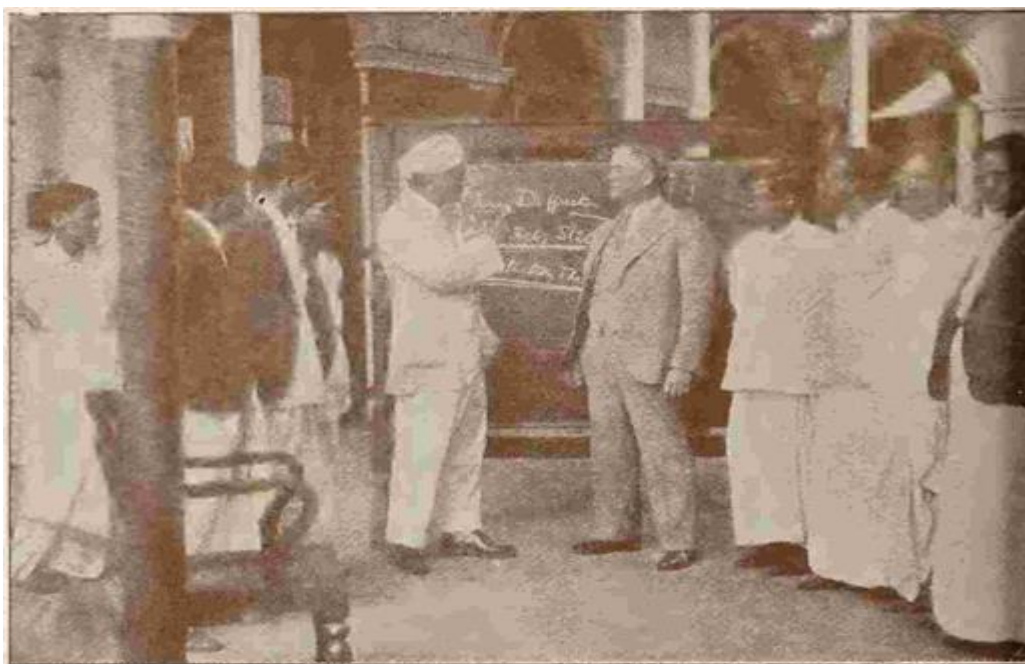
Group photograph : Accountant- General Office, Rangoon



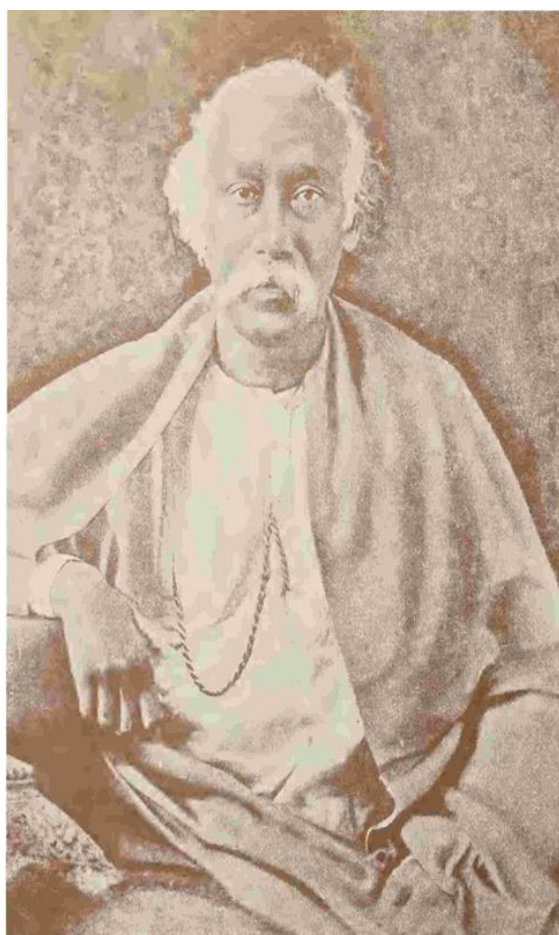
The Esplanade, Calcutta



The Indian Association for the Cultivation of Science



Seminar at the Indian Association



Mahendra Lal Sircar



Church in Scots Lane
Church in Scots Lane



Gharries in the monsoon
Gharries in the monsoon

Sommerfeld at Science College



Group Photo, Calcutta University



Raman with his wife, Lokasundari



Group Photo, Science College, Calcutta



Raman with spectrograph and Raman Tube



First Raman spectra photographed

STUDENTS OF RAMAN



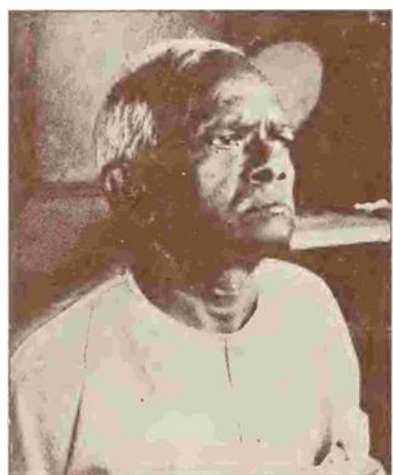
KR Ramanathan



KS Krishnan



Seshagiri Rao



Ashutosh Dey



S Ramachandra Rao



D Ramakrishna Rao



Kameswara Rao



AS Ganeshan



Raman receiving the Nobel Prize from the King of Sweden



CV Raman and the other Nobel Prize winners of 1930 (Hans Fischer) Karl Landsteiner and Sinclair Lewis)



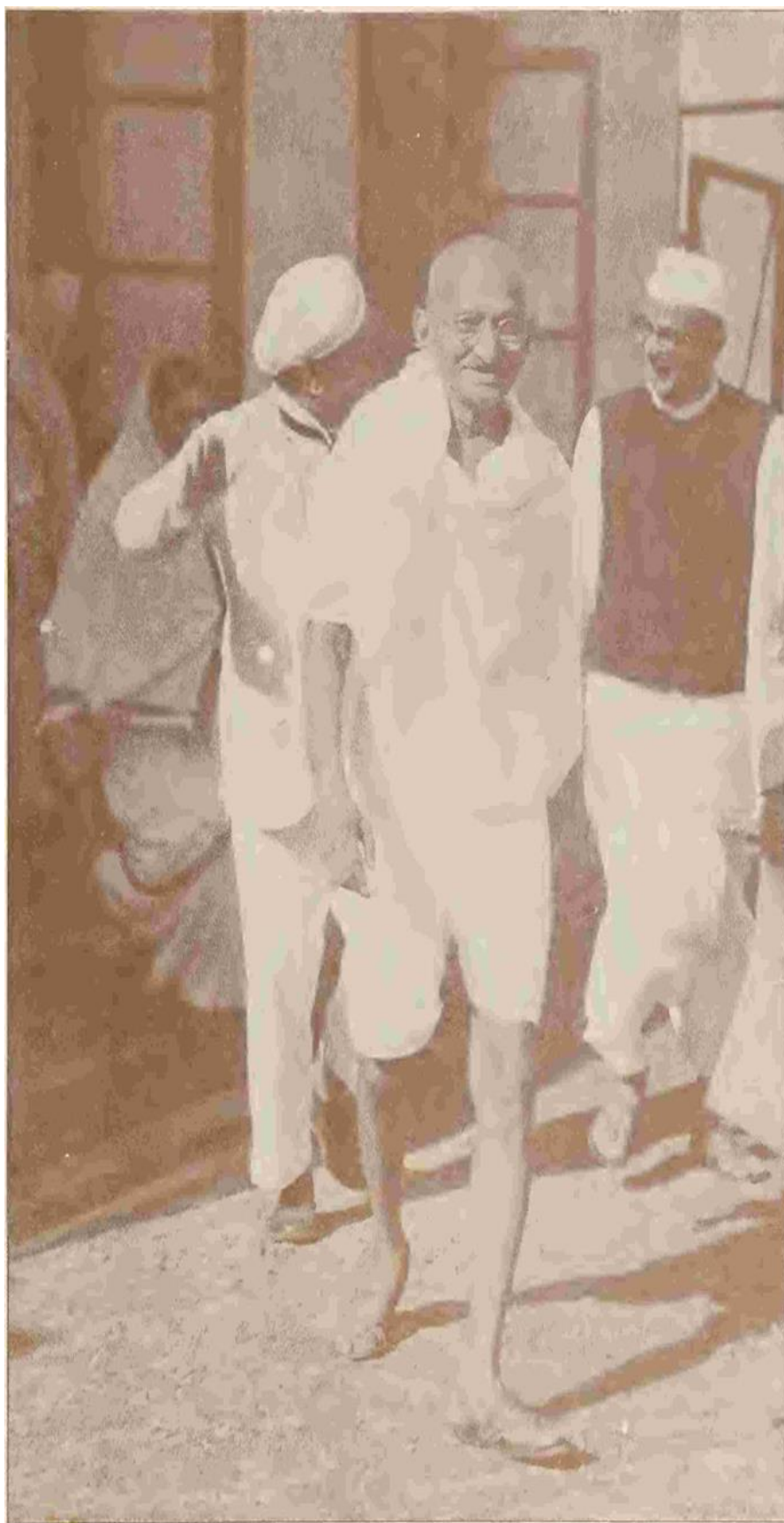
Nobel Ceremony - Raman first row extreme left sitting under the British Flag



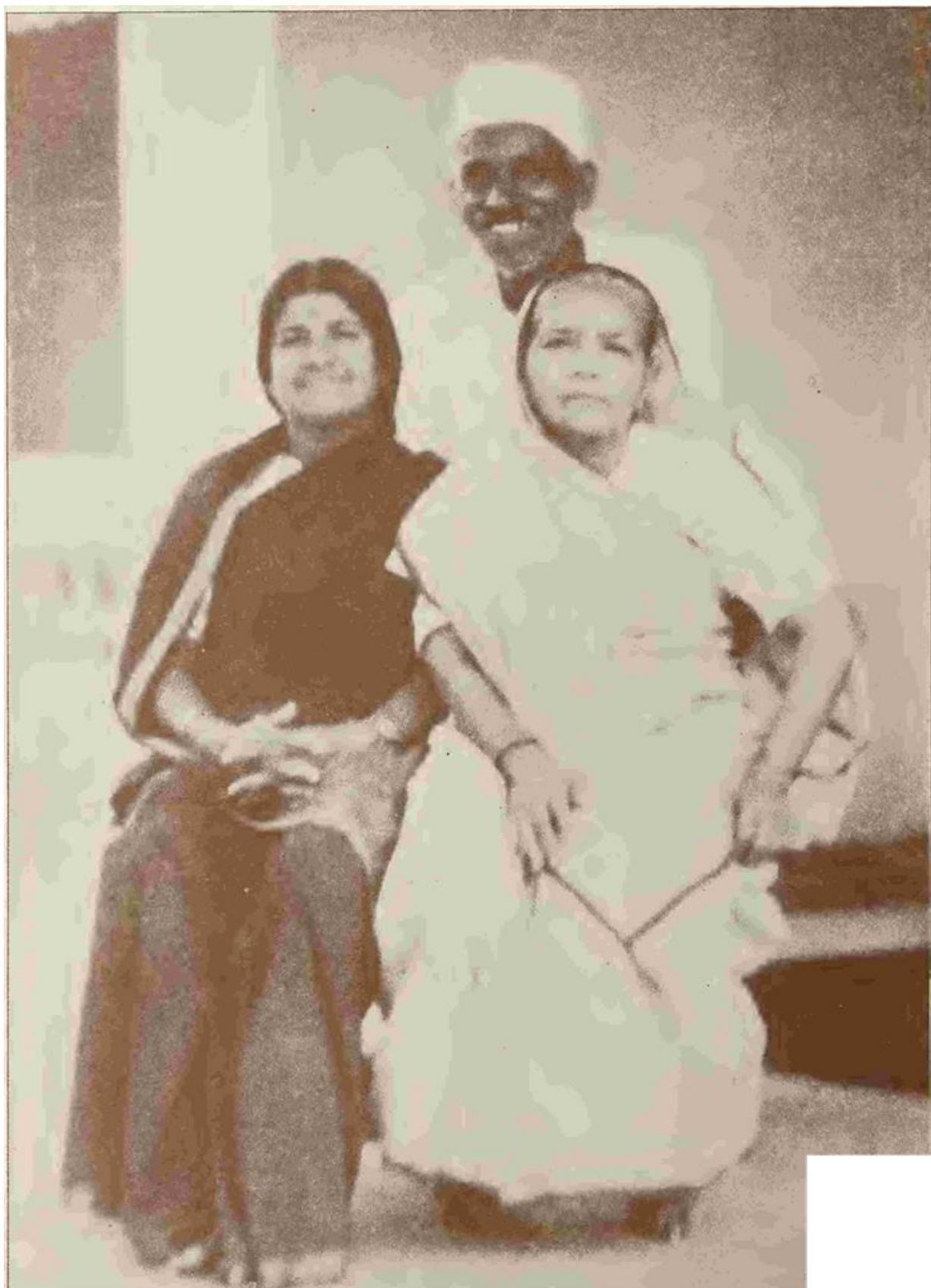
Raman and Lokasundari in Stockholm



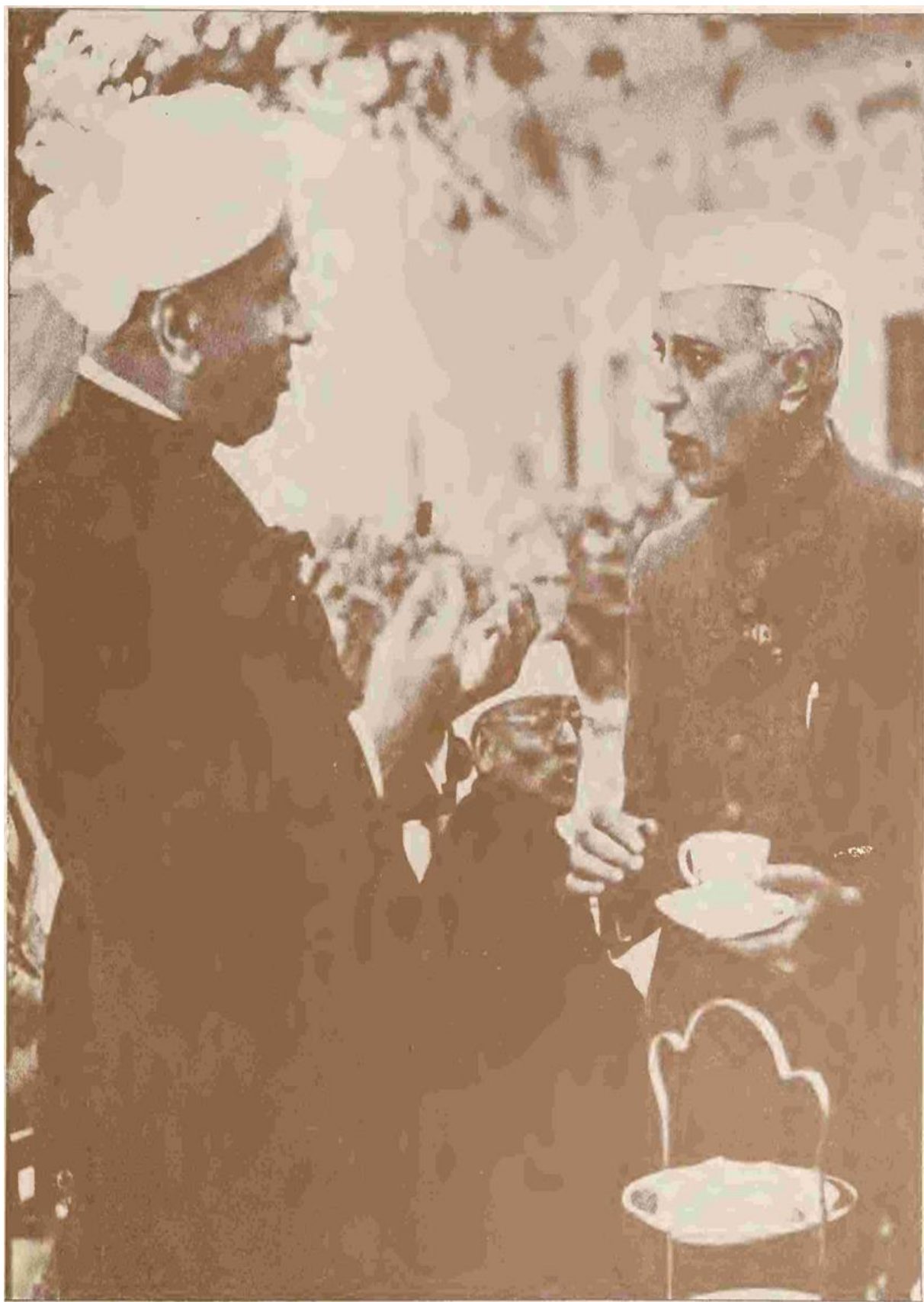
Lokasundari and Princess Ingrid of Sweden



With Mahatma Gandhi and Mohadeo Desai



Lokasundari with Kasturba Gandhi



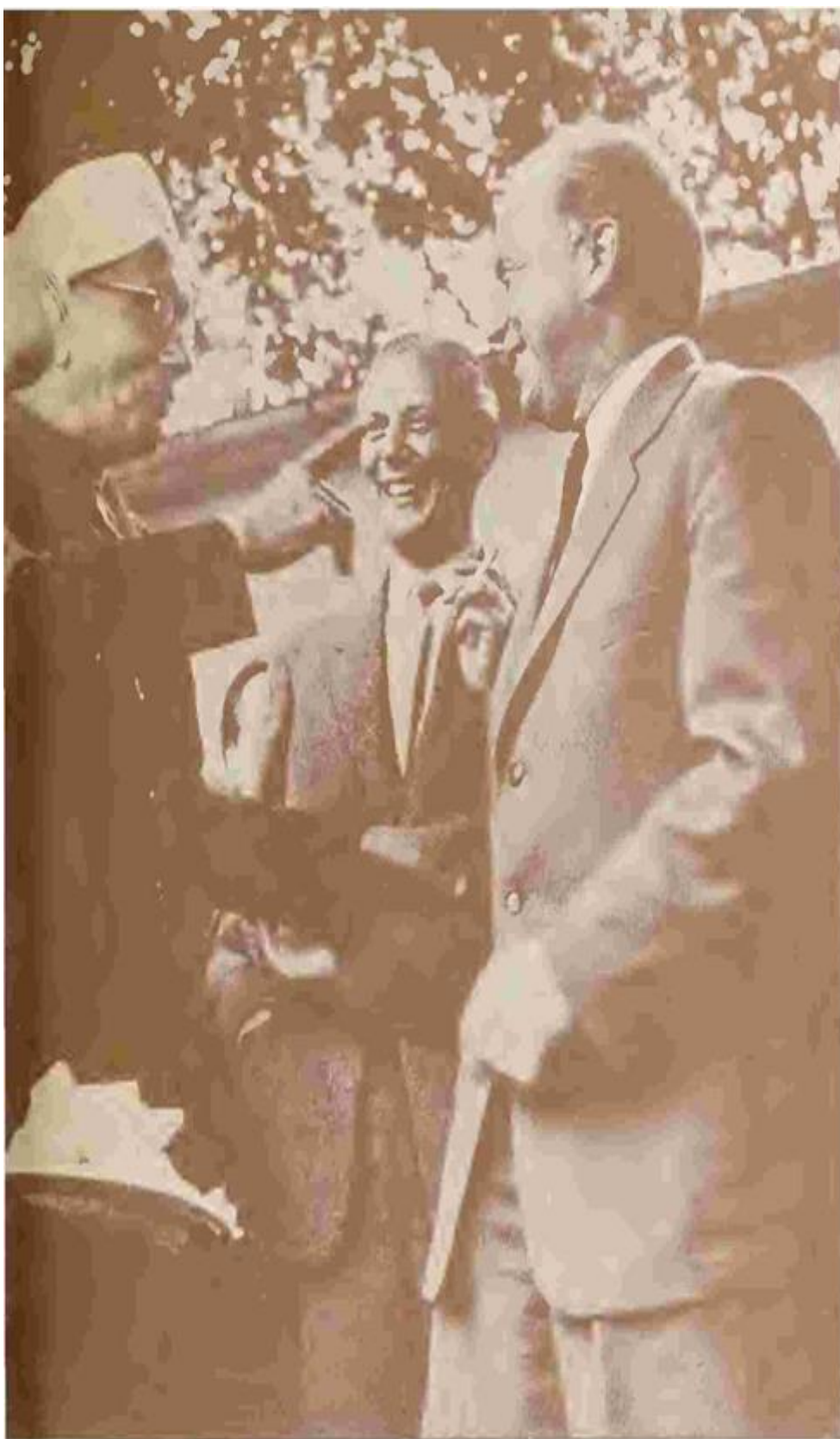
With Jawaharlal Nehru



CV Raman with Rajendra Prasad



CV Raman with Zakir Hussain



Raman with Heisenberg



Raman with Dirac



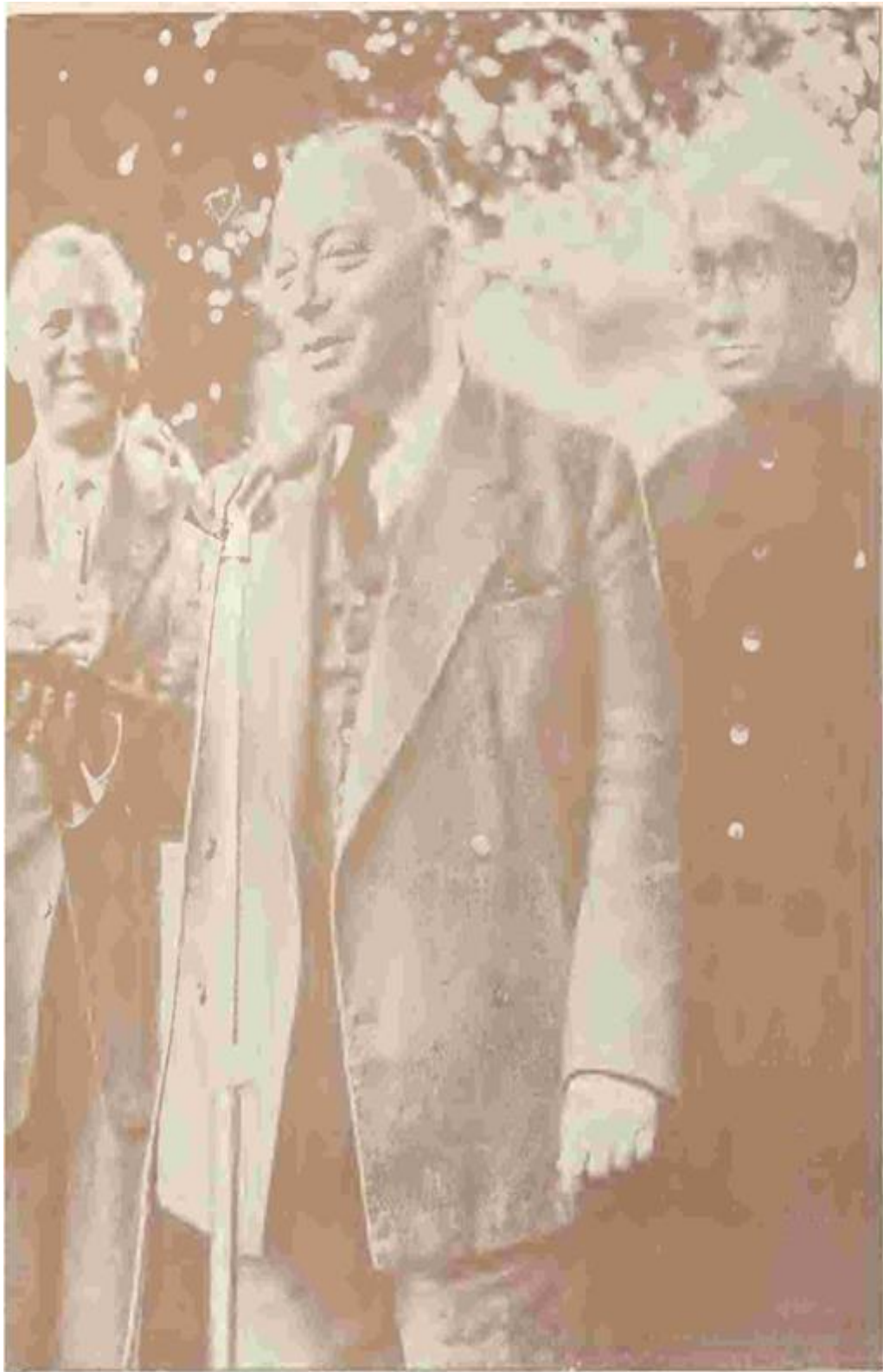
Raman with other Nobel Prizemen at the Lindau Conference



Ra111an showing diamonds to Bernal



Raman with Yukawa



Raman with Pauli



Inauguration of Indian Academy of Sciences Sir Mirza Ismail and
Prof Max Born on either side of CV Raman



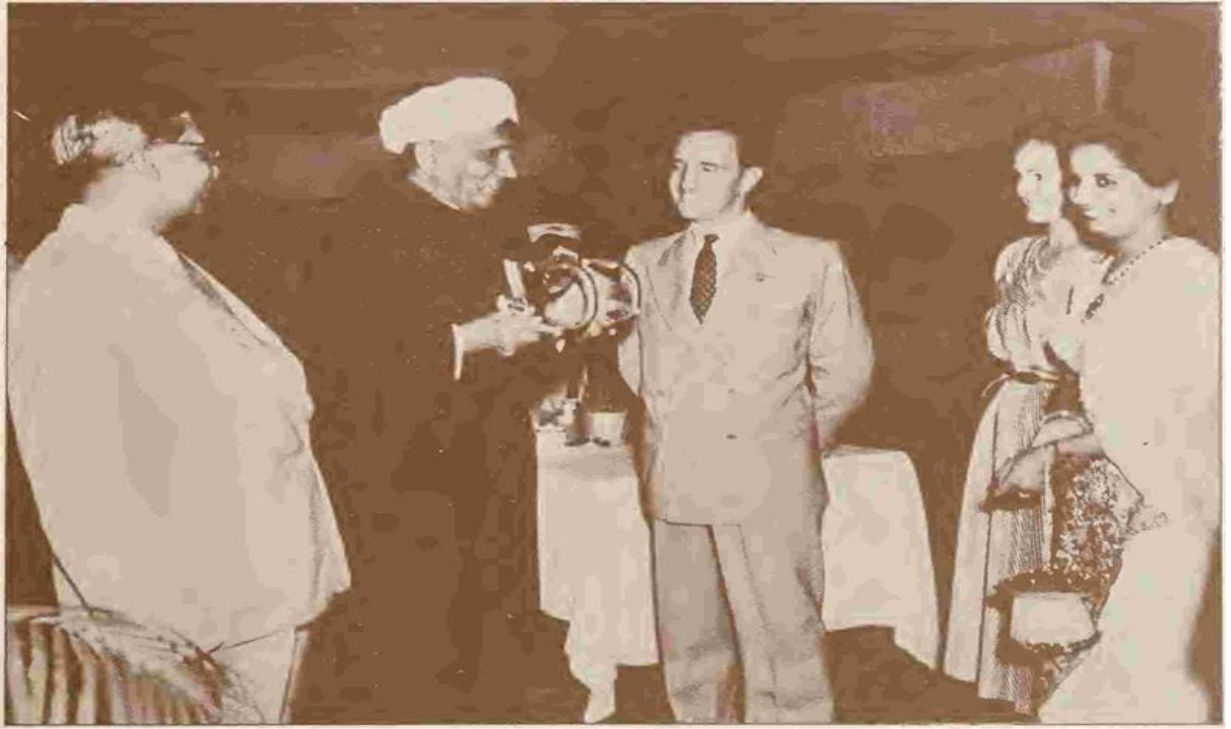
Sir T Vijayaraghavachariar, Arcot Ramaswami Mudaliar & CV Raman



CV Raman with delegates of IASc



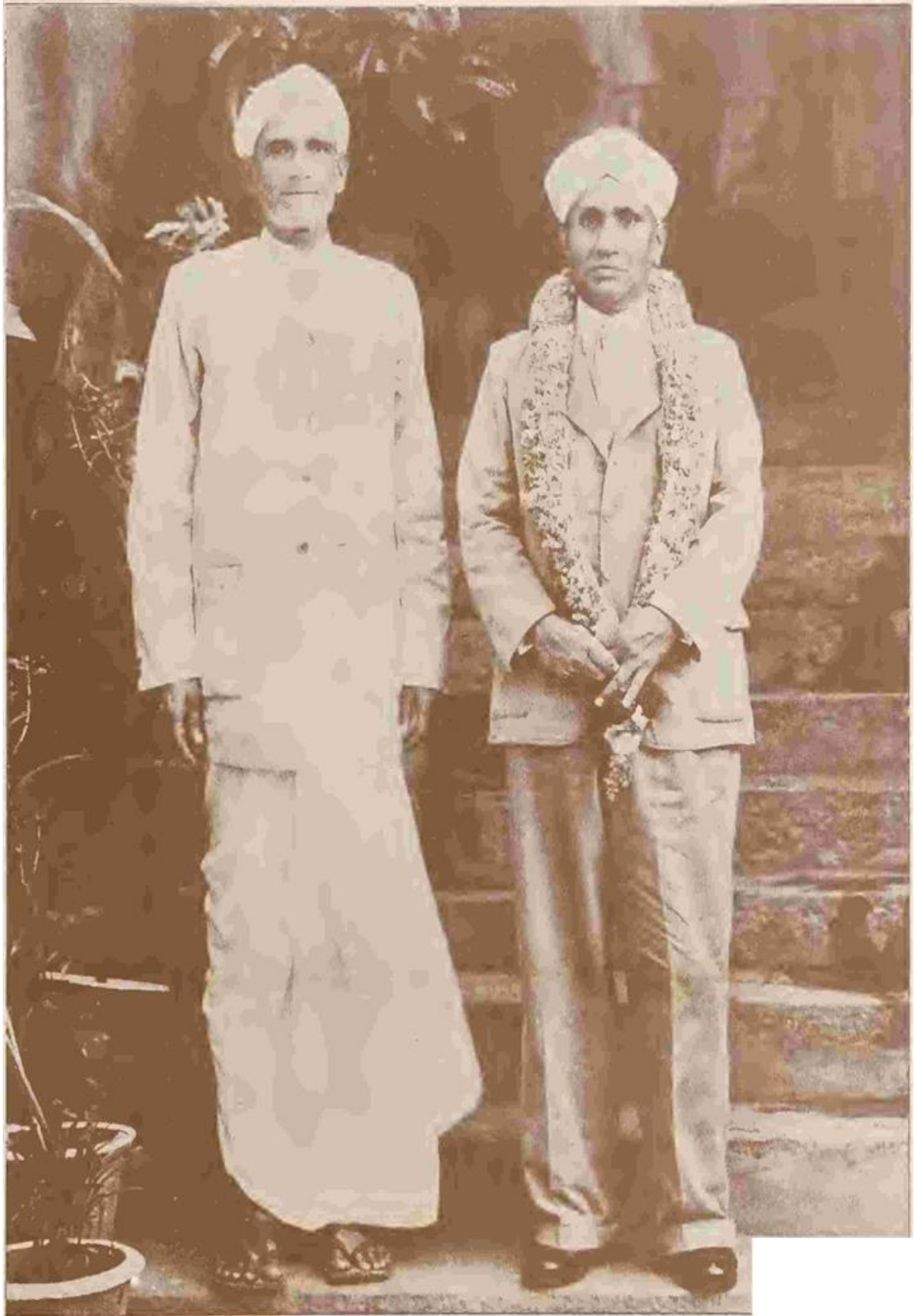
At Hyderabad: Raman talking to S Bhagavantam



Sir JC Ghosh and Sir CV Raman



Alladi Krishnaswamy Iyer (extreme left) Sir PS Sivaswami Ayyer (fourth from left) and others with Raman



Raman and PE Subrahmania Iyer

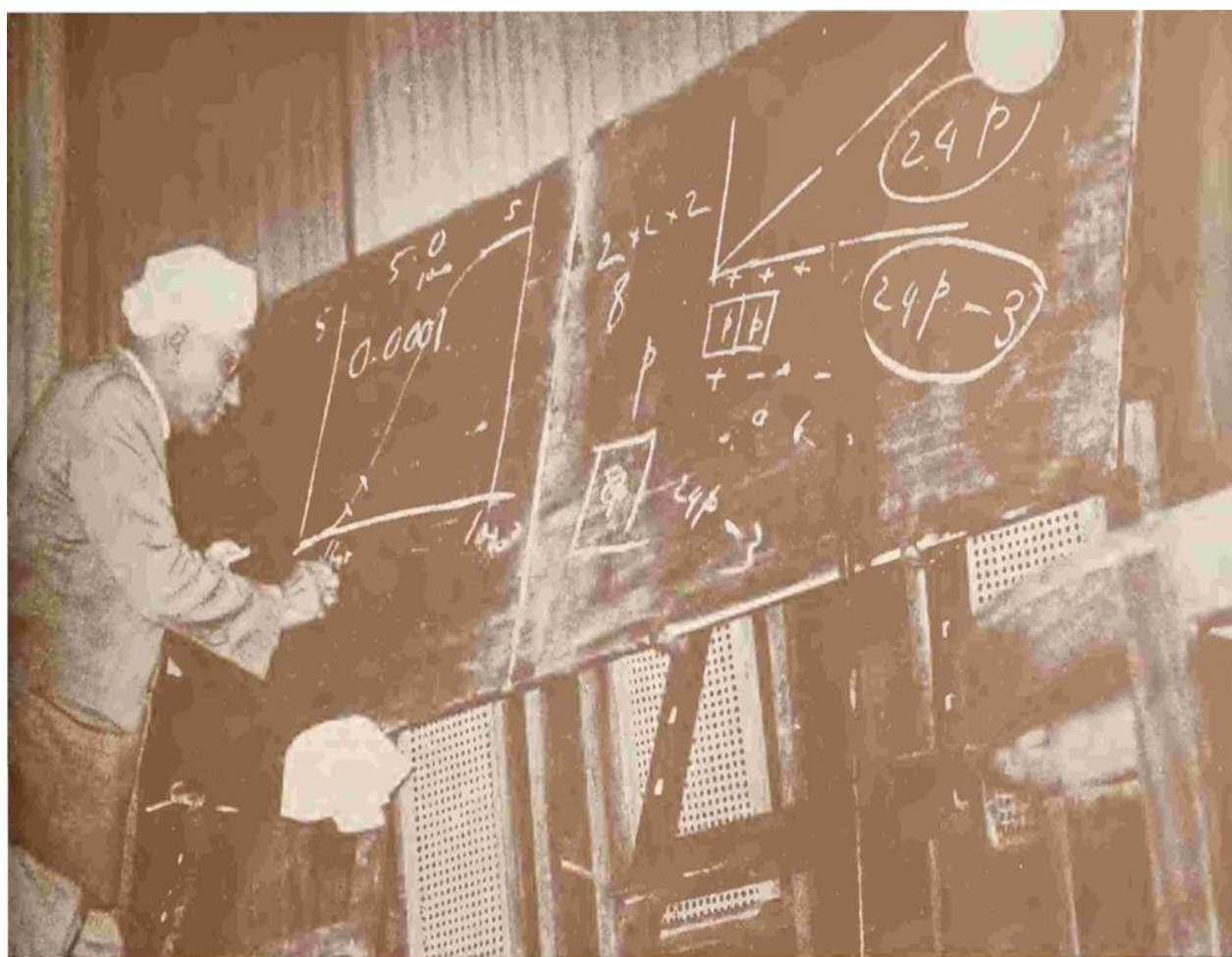


Raman and RA Millikan





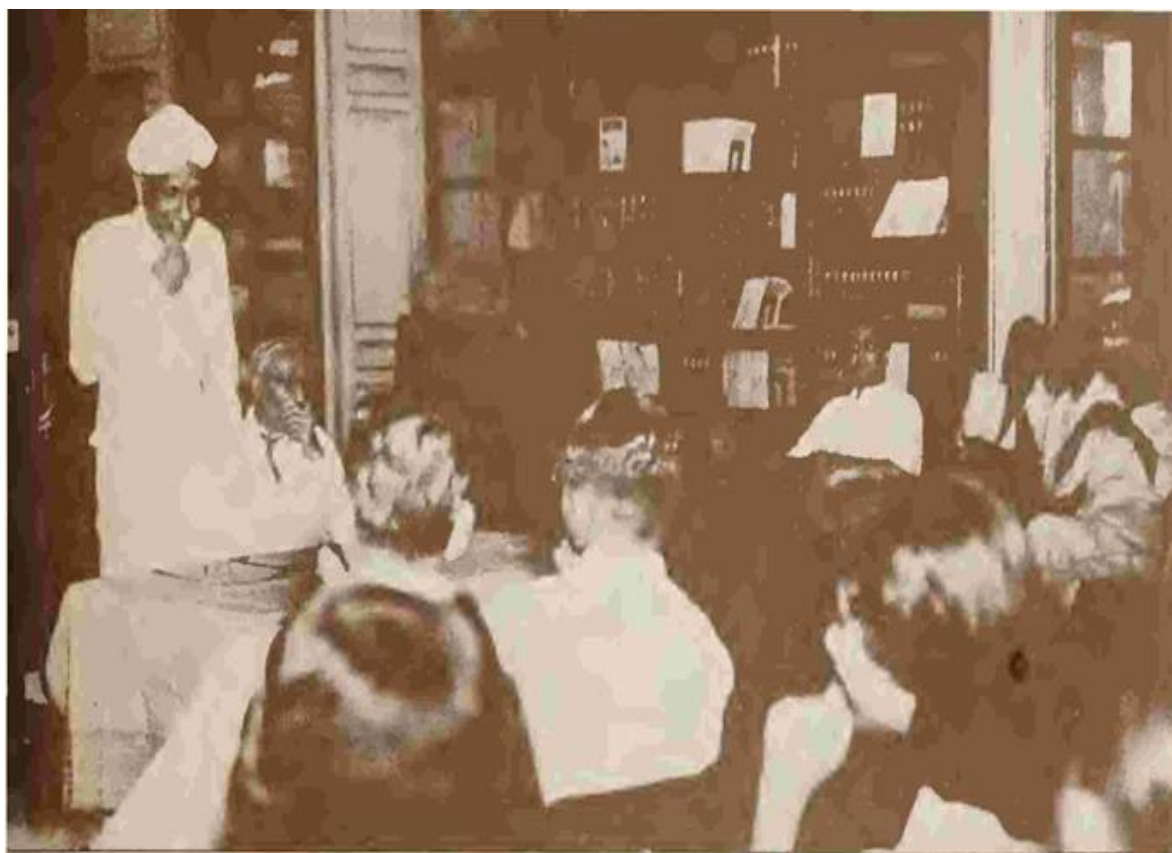




Raman expounding his crystal dynamics



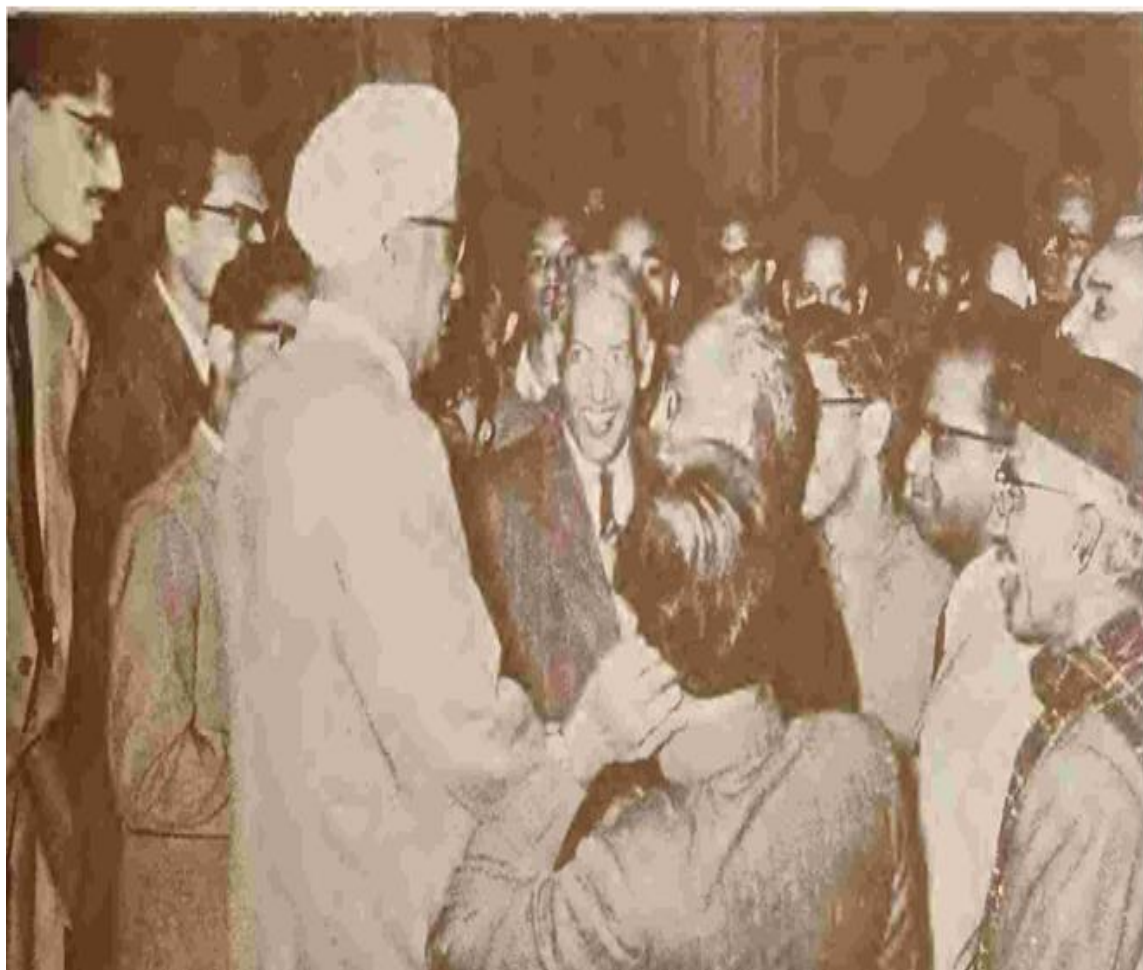
Lecture in Europe



Raman giving a Seminar



Seminar at Brooklyn, USA



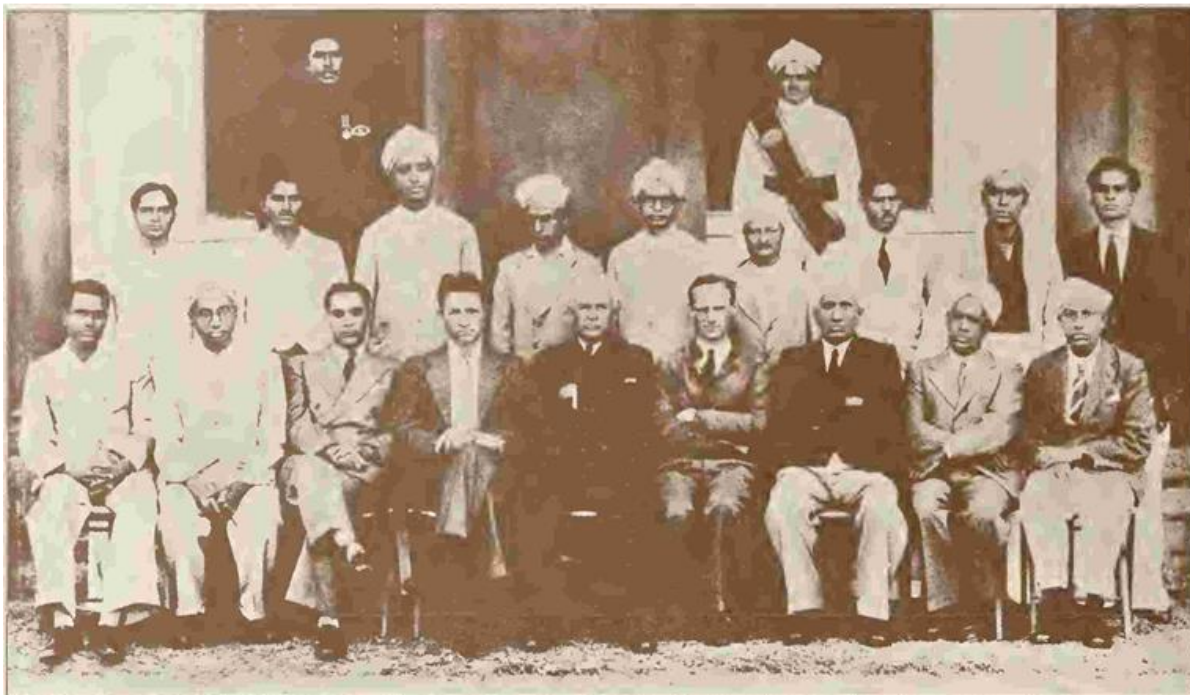
Raman with Scientists



The Indian Institute of Science



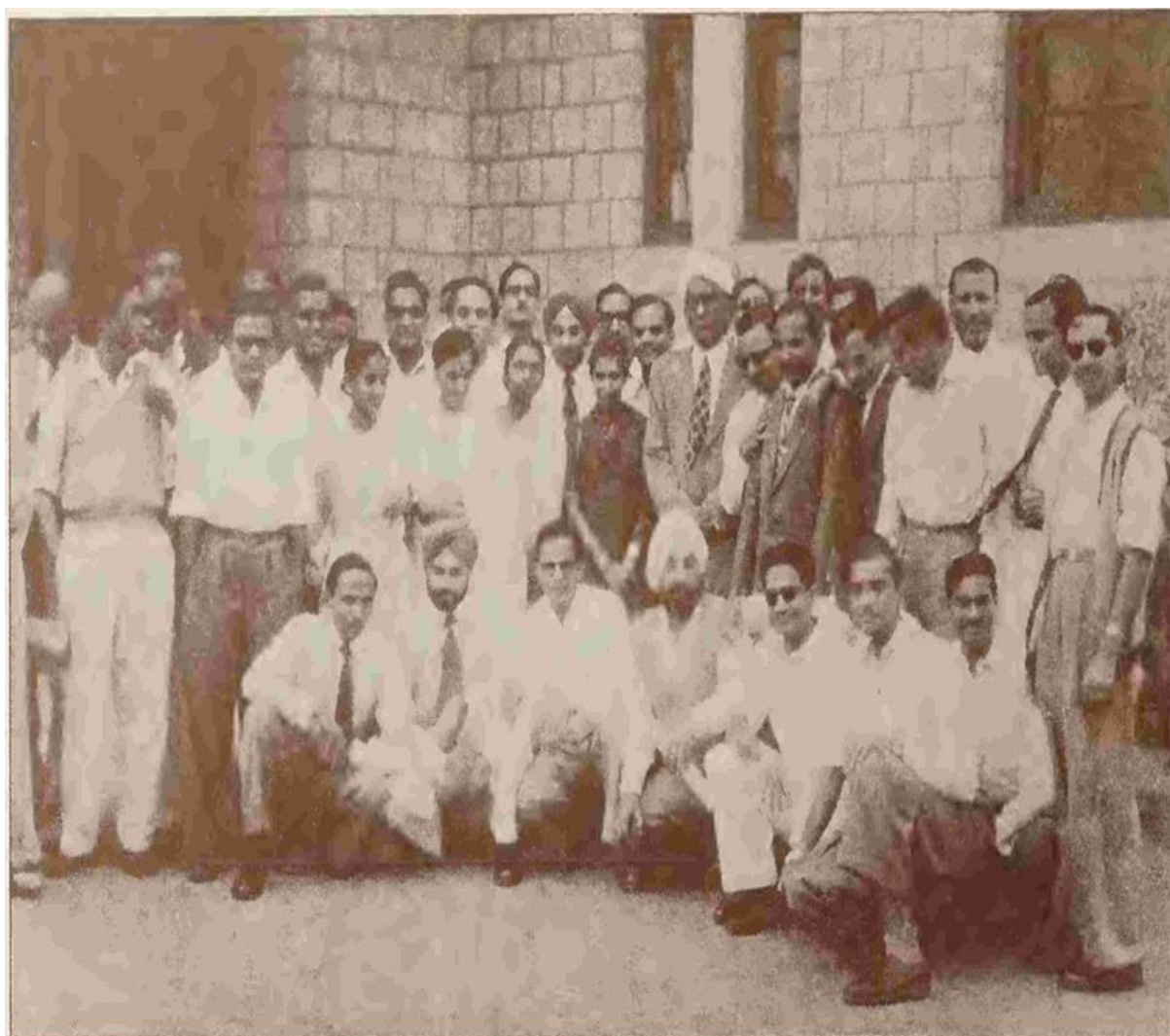
JN Tata Statue



Group photo: - IISc: Bhabha, Neher, Millikan,
Pickering, Raman and Ramanathan



Ra man Research Institute - early stages of construction, 1948 - 1949



Student visitors at the Raman Research Institute



Raman's Meeting with Nehru & others ...

Journal of Raman Spectroscopy

<https://analyticalsciencejournals.onlinelibrary.wiley.com/journal/10974555>

OVERVIEW

Aims and Scope

The *Journal of Raman Spectroscopy* is an international journal dedicated to the publication of original research at the cutting edge of all areas of science and technology related to Raman spectroscopy. The journal seeks to be the central forum for documenting the evolution of the broadly-defined field of Raman spectroscopy that includes an increasing number of rapidly developing techniques and an ever-widening array of interdisciplinary applications.

Such topics include time-resolved, coherent and non-linear Raman spectroscopies, nanostructure-based surface-enhanced and tip-enhanced Raman spectroscopies of molecules, resonance Raman to investigate the structure-function relationships and dynamics of biological molecules, linear and nonlinear Raman imaging and microscopy, biomedical applications of Raman, theoretical formalism and advances in quantum computational methodology of all forms of Raman scattering, Raman spectroscopy in archaeology and art, advances in remote Raman sensing and industrial applications, and Raman optical activity of all classes of chiral molecules.

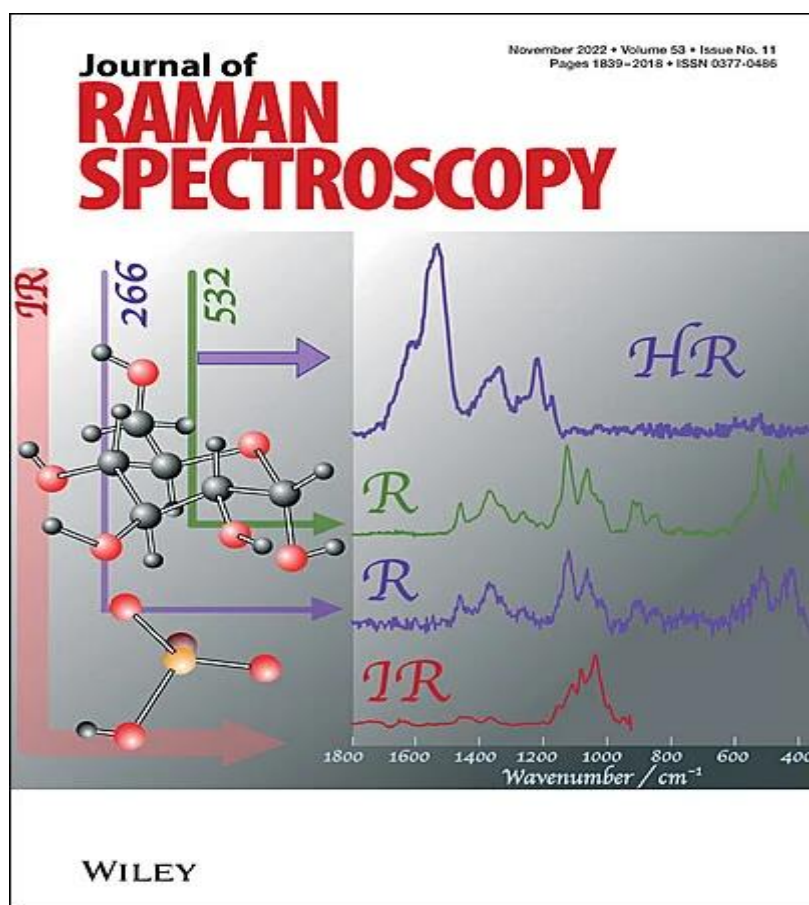
Readership

Chemists · physicists · bioscientists · materials scientists · spectroscopists · analytical scientists

Abstracting and Indexing Information

- Advanced Technologies & Aerospace Database (ProQuest)
- Agricultural & Environmental Science Database (ProQuest)
- Biological Science Database (ProQuest)

- CAS: Chemical Abstracts Service (ACS)
- Chemical Abstracts Service/SciFinder (ACS)
- ChemWeb (ChemIndustry.com)
- Chimica Database (Elsevier)
- Current Contents: Physical, Chemical & Earth Sciences (Clarivate Analytics)
- INSPEC (IET)
- Journal Citation Reports/Science Edition (Clarivate Analytics)
- Materials Science & Engineering Database (ProQuest)
- Natural Science Collection (ProQuest)
- Science Citation Index (Clarivate Analytics)
- Science Citation Index Expanded (Clarivate Analytics)
- SciTech Premium Collection (ProQuest)
- SCOPUS (Elsevier)
- Technology Collection (ProQuest)
- VINITI (All-Russian Institute of Science & Technological Information)
- Web of Science (Clarivate Analytics)



RYSI Award

<https://www.ramanaward.org/rysi-award/rysi-overview/>



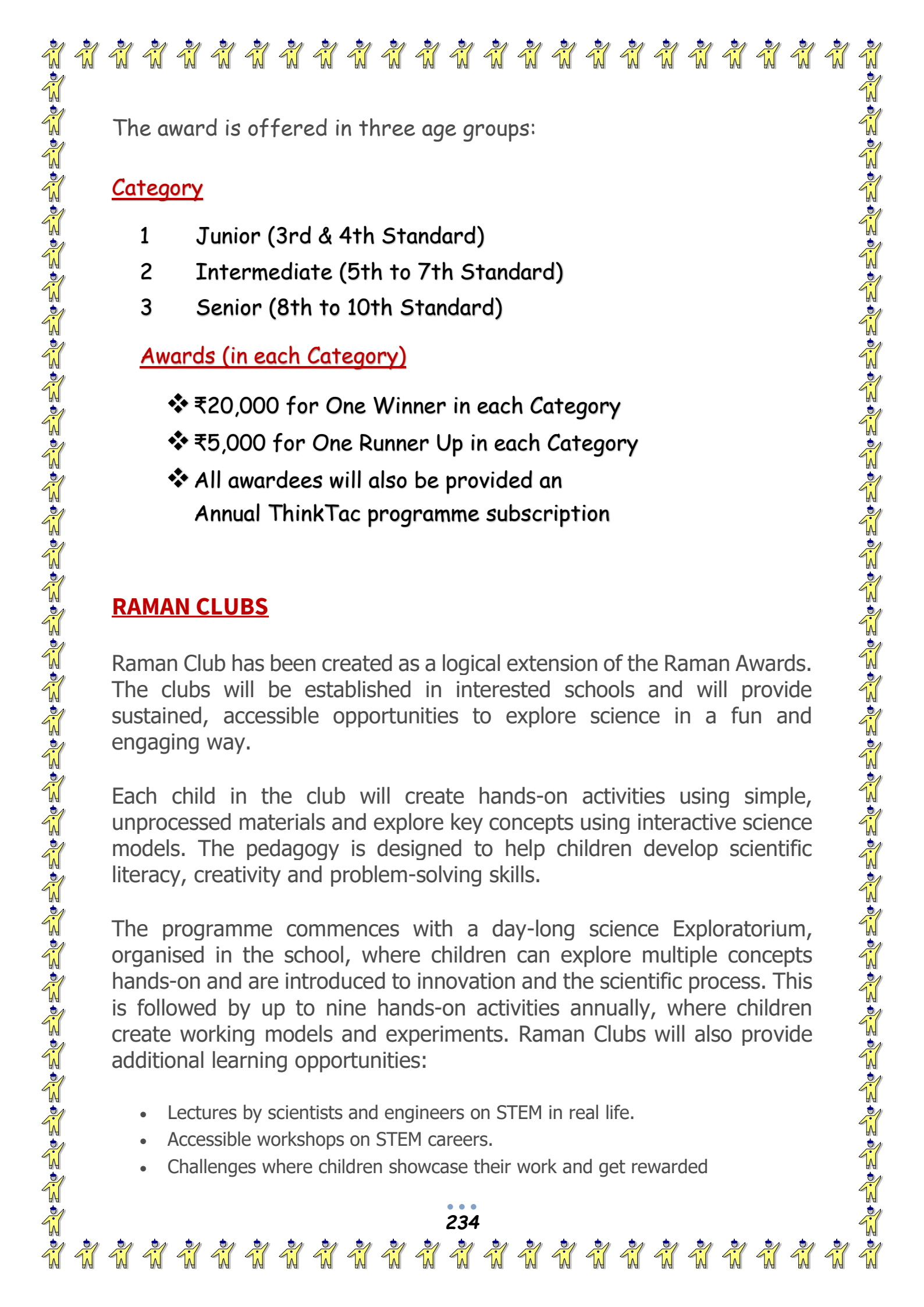
Raman Young Science Innovator Award

The Award is instituted by the Raman Research Institute Trust and Innovation and Science Promotion foundation (ISPF) and sponsored by ThinkTac.

The RYSI Award has been instituted to create interest in science at a young age, leading to more children taking up STEM as a career. The award aims to establish Science as a Fun and interesting activity that can be explored anywhere with simple materials.

The award, commemorating the discovery of the Raman Effect on 28th February 1928 is open to all children studying in standards III to X.

Participants are expected to create hands-on science activities that demonstrate a principle in the selected topic. Working models, toys or experiments that help demonstrate a scientific principle maybe submitted.



The award is offered in three age groups:

Category

- 1 Junior (3rd & 4th Standard)
- 2 Intermediate (5th to 7th Standard)
- 3 Senior (8th to 10th Standard)

Awards (in each Category)

- ❖ ₹20,000 for One Winner in each Category
- ❖ ₹5,000 for One Runner Up in each Category
- ❖ All awardees will also be provided an Annual ThinkTac programme subscription

RAMAN CLUBS

Raman Club has been created as a logical extension of the Raman Awards. The clubs will be established in interested schools and will provide sustained, accessible opportunities to explore science in a fun and engaging way.

Each child in the club will create hands-on activities using simple, unprocessed materials and explore key concepts using interactive science models. The pedagogy is designed to help children develop scientific literacy, creativity and problem-solving skills.

The programme commences with a day-long science Exploratorium, organised in the school, where children can explore multiple concepts hands-on and are introduced to innovation and the scientific process. This is followed by up to nine hands-on activities annually, where children create working models and experiments. Raman Clubs will also provide additional learning opportunities:

- Lectures by scientists and engineers on STEM in real life.
- Accessible workshops on STEM careers.
- Challenges where children showcase their work and get rewarded

- Immersive experience in scientific/academic organisations*
- Mentorship by Scientists and Engineers of repute*
- Opportunity to become a Raman Science Ambassador*

Raman Club Mentors, certified teachers who receive special training in the scientific process and engaging children, would facilitate the programmes.

Apart from training and support, mentors will have access to exclusive content, including DIY guides and videos, concept connect videos and exploration.

Raman clubs are already active in 50 Government schools in Vijayanagara, Davanagere, Chikmagalur, Dharwad and Bengaluru, and 25 more are in the process of being setup.

Schools will need to pay a subsidised annual cost of ₹ 30,000, which includes the cost of materials and support. Government and low-income schools will be supported by private donors and CSR.



CV Raman Birth Centenary Award

https://sciencecongress.nic.in/c_v_raman_c2.php

To commemorate the birth centenary of Sri C. V. Raman, Nobel Laureate, the Indian Science Congress Association instituted this annual award in 1989 to honour a distinguished scientist of the country every year.

The award carries a Gold Medal and Certificate. The awardee is entitled to T.A. (Air Fare-economy class - within the country) as per ISCA rules for attending the Annual session of the Science Congress in which he/she will receive the award.

The award is presented to the recipient either in the inaugural or Valedictory function of the Annual Session of The Indian Science Congress Association.

Nominations for the Birth Centenary Award are invited from Members of ISCA Council.

The Executive Committee in its meeting held on October 13, 2012 resolved that a person shall not be eligible for more than one award /lecture in his lifetime. No one (except ISCA young scientist awardees) shall be given the second ISCA award under any circumstances.

The Executive Committee in its meeting held on January 01, 2019 resolved that while selecting ISCA awardees for ISCA awards their H index and Citation index (in SCOPUS and Google Scholar) would be taken into account.

The Executive Committee in the Meeting held on October 15, 2019 resolved that for this Birth Centenary awards any life member of not less than Ten years of standing or continuous Annual Member of not less than Ten years of standing and also with Ten years of teaching and research experience in University/College or as a scientist in Government recognized Laboratory/ institution can be nominated by a Council member. It is also recommended that the heads of the organizations which are providing funds to ISCA in any form cannot be nominated by a Council member for consideration of any award.

The awardee may be requested to deliver a lecture at ISCA Headquarters/ Chapters.

The final selection of the award is made by a Selection Committee comprising the General President, Two General Secretaries, Treasurer out of the candidates nominated.

The last date for receiving nominations is **July 31** each year.



Annotated

Webliography



Whereas a bibliography lists books and other printed works referenced in a research paper, a webliography, a new research product born out of web research, represents a list of websites used. To annotate means to write a few sentences that both describe and critique the website. When instructors assign an annotated webliography, they want students to defend the inclusion of the websites as references in the research paper. In the annotation, speak to the website's authority, credibility and relevance to your research subject.

Sometimes, we are asked to compile and present our bibliographies to our professors before we turn in our actual essays. We might be asked to comment on our sources to help establish a context for how we will use them, as well as to describe how we have evaluated them as a worthy authority over information. To do this, not only do we supply the list of sources, we write out a paragraph for each of them that details these considerations. This is called an "annotated bibliography."

Webliography Defined

Bibliography- lists books and other printed works referenced in a research paper

Webliography- a product born out of web research, represents a list of websites used

Annotate- to write a few sentences that both describe and critique the website

Very large quantity of information, details, data, etc., were obtained in several websites during the process of this book - "Nobel Laureate Sir CV RAMAN". Wherever possible reference have been provided by indicating the sources/resources [web links & websites]. It is experienced that it is practically impossible to cover all and exhaustive details of him. Therefore, is has been decided that a list of selected web sources is made available to the readers and so that the readers could reach these sources to reach a wider and exhaustive areas to know about the scientist. While doing so, these web sources have been duly and neatly annotated and, thus readers could get more information and benefits.

List of Selected Web sources

[01] <https://archive.org/details/scientificpapers0001rama>

C. V. Raman (1888-1970) was awarded the Nobel Prize for Physics in 1930 for the discovery of the Raman Effect, one of the most significant experimental discoveries of the 20th century. His scientific papers - 465 papers running to 4170 pages - were compiled by Prof S Ramaseshan and these 6 volumes were published by Indian Academy of Sciences, Bangalore in 1988 and distributed Oxford University Press. In bringing out the six volumes of the scientific papers of C V Raman many individuals and institutions have contributed. **This web link leads to Volume I having 94 papers in 616 pages on the topic: Scattering of Light.**

[02] <https://archive.org/details/scientificpapers0000rama>

C. V. Raman (1888-1970) was awarded the Nobel Prize for Physics in 1930 for the discovery of the Raman Effect, one of the most significant experimental discoveries of the 20th century. His scientific papers - 465 papers running to 4170 pages - were compiled by Prof S Ramaseshan and these 6 volumes were published by Indian Academy of Sciences, Bangalore in 1988 and distributed Oxford University Press. In bringing out the six volumes of the scientific papers of C V Raman many individuals and institutions have contributed. **This web link leads to Volume II having 55 papers in 672 pages on the topic: Acoustics.**

[03] https://archive.org/details/scientificpapers0000rama_x8l1

C. V. Raman (1888-1970) was awarded the Nobel Prize for Physics in 1930 for the discovery of the Raman Effect, one of the most significant experimental discoveries of the 20th century. His scientific papers - 465 papers running to 4170 pages - were compiled by Prof S Ramaseshan and these 6 volumes were published by Indian Academy of Sciences, Bangalore in 1988 and distributed Oxford University Press. In bringing out the six volumes of the scientific papers of C V Raman many individuals and institutions have contributed. **This web link leads to Volume III having 66 papers in 584 pages on the topic: Optics.**

[04] https://archive.org/details/scientificpapers0000rama_r1r0

C. V. Raman (1888-1970) was awarded the Nobel Prize for Physics in 1930 for the discovery of the Raman Effect, one of the most significant experimental discoveries of the 20th century. His scientific papers - 465 papers running to 4170 pages - were compiled by Prof S Ramaseshan and these 6 volumes were published by Indian Academy of Sciences, Bangalore in 1988 and distributed Oxford University Press. In bringing out the six volumes of the scientific papers of C V Raman many individuals and institutions have contributed. **This web link leads to Volume IV having 76 papers in 774 pages on the topic: Optics of Minerals and Diamond.**

[05] <https://archive.org/details/scientificpapers05rama>

C. V. Raman (1888-1970) was awarded the Nobel Prize for Physics in 1930 for the discovery of the Raman Effect, one of the most significant experimental discoveries of the 20th century. His scientific papers - 465 papers running to 4170 pages - were compiled by Prof S Ramaseshan and these 6 volumes were published by Indian Academy of Sciences, Bangalore in 1988 and distributed Oxford University Press. In bringing out the six volumes of the scientific papers of C V Raman many individuals and institutions have contributed. **This web link leads to Volume V having 89 papers in 882 pages on the topic: Physics and Crystals.**

[06] <https://archive.org/details/scientificpapers0006rama>

C. V. Raman (1888-1970) was awarded the Nobel Prize for Physics in 1930 for the discovery of the Raman Effect, one of the most significant experimental discoveries of the 20th century. His scientific papers - 465 papers running to 4170 pages - were compiled by Prof S Ramaseshan and these 6 volumes were published by Indian Academy of Sciences, Bangalore in 1988 and distributed Oxford University Press. In bringing out the six volumes of the scientific papers of C V Raman many individuals and institutions have contributed. **This web link leads to Volume VI having 85 papers in 642 pages on the topic: Floral Colours and Visual Perceptions.**

[07] [https://www.newworldencyclopedia.org/entry/C. V. Raman](https://www.newworldencyclopedia.org/entry/C._V._Raman)

The New World Encyclopedia (NWE) is designed to organize human knowledge so the reader will learn information not just for its own sake, but for its value to the reader and the world as a whole. It is designed to provide the context and values of our social and organizational relationships, and our relationship with nature and the environment. The underlying goal of the encyclopedia is to promote knowledge that leads to human happiness, well-being, world peace. It is a useful tool for everyone, and an ideal resource for student research.

New World Encyclopedia is a wiki-based encyclopedia which contains carefully selected articles that are rewritten and supervised by a team of editors with academic and literary qualifications. *New World Encyclopedia* has the same ease of use as *Wikipedia*, but differs based on an editorial policy that includes a more rigorous article selection process, editorial review process, and its wholesome values orientation.

Sir Chandrasekhara Venkata Raman, CBE (November 7, 1888 - November 21, 1970) was an Indian physicist, who was awarded the 1930 Nobel Prize in Physics for his work on the scattering of light and his discovery of a unique form of scattering known as Raman scattering or the Raman effect. This effect is useful for analyzing the compositions of solids, liquids, and gases. It can also be used to monitor manufacturing processes and to diagnose diseases.

This web link provides the details of Sir CV Raman in nine major headings, each containing the relevant and more appropriate information about the scientist. Also, it includes an elaborate list of bibliography arranged year-wise.

[08] [https://ia800208.us.archive.org/25/items/RamanCentennial/CV Raman.pdf](https://ia800208.us.archive.org/25/items/RamanCentennial/CV_Raman.pdf)

With indefatigable energy and a European intensity no other Indian scientist exhibited in the period 1907 to 1933 Raman created and sustained a school of physics in Calcutta that in Sommerfeld's words made this country 'an equal partner with her European and American sisters'.

A Special Centennial Issue ["CV Raman 1888 Centennial 1988"] was released by Journal of the Indian Institute of Science [Vol.68, Nos.11-12, Nov-Dec 1988], ISSN: 0019 - 4964. In one-day symposium arranged by IISc, a group of distinguished to speak about Raman's life and work was invited. This special issue contains the texts of these talks, some rare photographs, and reprints of some

of Raman's most significant papers. **This web link takes the readers to all these interesting details and other rare information about Sir CV Raman.**

[09] https://www.ias.ac.in/public/Resources/Other_Publications/e-Publications/003/Chandrasekhara_Venkata_Raman.pdf

Sir CV Raman was a towering and dynamic scientific leader who inspired generations of students he trained in the methodology of research. He created the school of physics in Calcutta first, and then in Bangalore. His disciples came from all parts of India. He kindled their scientific interest and curiosity, and communicated to them the scientific spirit and the joy of scientific research. Biographies of great personalities in science are, therefore, all the more precious documents. When written by their contemporaries, especially if by one of their close associates, they are invaluable. Here is an authoritative biography of the most unique scientific personality of modern India, written with genuine understanding and admiration but with critical judgment and honesty which do not avoid the discussion of the all too human limitations of a great man. Here is an authoritative biography of the most unique scientific personality of modern India, written with genuine understanding and admiration but with critical judgment and honesty which do not avoid the discussion of the all too human limitations of a great man.

A brief detail - Forewords and Preface - of this Memoir is produced in our book and also its web link is provided. **This web link enables the readers to reach and read all the interesting chapters about Sir CV Raman.**

[10] https://www.researchgate.net/figure/A-timeline-of-events-and-discoveries-in-the-history-of-Raman-spectroscopy-Nobel-Prizes_fig1_236976835

ResearchGate was started in 2008 to address the problems we saw in the way science is created and shared. Their mission is to connect the world of science and make research open to all. The 20 million researchers in science community come from diverse sectors in over 190 countries, and use ResearchGate to connect, collaborate, and share their work. **This web link provides the elaborate details of Raman spectroscopy and other relevant [textual and graphical] information about Raman's life, scientific achievements, getting the Nobel prize and his exemplary contribution to Physics.**



[11] <https://history.aip.org/phn/11807016.html>

The American Institute of Physics (AIP) was founded in 1931 in response to funding problems brought on by the Great Depression. At the urging of the Chemical Foundation, which provided initial funding, leaders of American physics formed a corporation for the "advancement and diffusion of knowledge of the science of physics and its application to human welfare," especially by achieving economies in the publishing of journals and the maintenance of membership lists.

Broader concerns also argued for cooperation. With the advent of esoteric theory in quantum, nuclear, and relativity physics, the worlds of academic and industrial physics seemed to be drifting apart. Moreover, because the public found physics hard to comprehend, some blamed science-based technology for the perils of modern warfare and economic collapse. Thus, from the outset the Institute also worked to foster cooperation within the physics community and to improve public understanding of science.

This web link offers over 1000 biographies of physicists and histories of institutions with information pertaining to their lives, careers, and research.

[12] <https://archive.org/details/cvramanpictorial00bang>

This is Birth Centenary Commemoration Volume was compiled by Prof S Ramaseshan and Prof C Ramachandra Rao and published by Indian Academy of Sciences, Bangalore in 1998. This Pictorial Biography, in fact, is the source for number of publications, books, films, videos, etc., in respect of Sir CV Raman. These pictures go back to the Golden Jubilee of the Raman Effect in 1978 which was celebrated by an International Conference on Raman Spectroscopy in Bangalore. This book's front wrapper contains the last photography of Sir CV Raman, a rare collection. This book contains a variety of pictures relating to Raman's life, scientific contribution, his association with great international physicists, his family, etc.,

This web link is an important source of information leading the readers to see, study, enjoy and understand Sir CV Raman in 360°.

[13] [https://www.ramanaward.org/rysi award/rysi overview/](https://www.ramanaward.org/rysi%20award/rysi%20overview/)

Raman Young Science Innovator [RYSI] Award is instituted by the Raman Research Institute Trust and Innovation and Science Promotion foundation (ISPF) and sponsored by ThinkTac. The RYSI Award has been instituted to create interest in science at a young age, leading to more children taking up STEM as a

career. The award aims to establish Science as a Fun and interesting activity that can be explored anywhere with simple materials. The RYSI Award aims at kindling the inherent interest about science in children. While the award does not intend to restrict the exploration of the children to specific areas of science, the programme needs to focus on selected topics so as to have a theme as well as common evaluation parameters for the competition.

The award, commemorating the discovery of the Raman Effect on 28th February 1928 is open to all children studying in standards III to X.

This web link leads to the details of the award, eligibility criteria, rules, amount of the award, etc.,

(😊) @ (😊) @ (😊) @ (😊)

**Films Division
Ministry of Information & Broadcasting
Govt. of India
24- Dr. G Deshmukh Marg
MUMBAI -400 026**

Dated 11th November, 2020

Biopic streamed as tribute to C.V. Raman

The 132nd birth anniversary of Prof. C.V. Raman, acclaimed Physicist, Nobel laureate and Bharat Ratna recipient who was instrumental in India's growth in the field of science and Physics in particular, has been celebrated on 7th November, 2020.



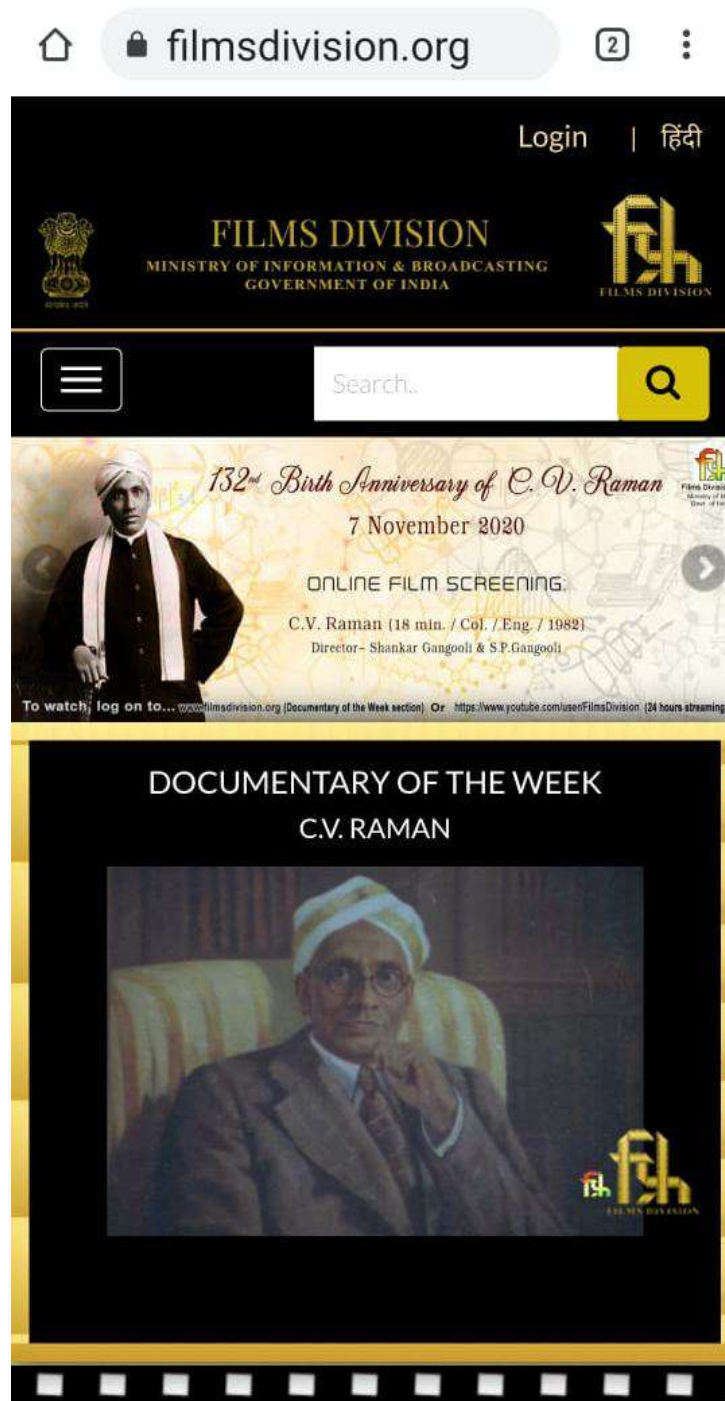
Films Division paid tribute to him by streaming a biopic, *C.V.Raman* (18 Min./ English) on <https://filmsdivision.org/DocumentaryoftheWeek> and <https://www.youtube.com/user/FilmsDivision> for 24 hours on 7th November, 2020. The documentary on Prof Raman throws light on his life and works including the groundbreaking work he did in the field of light scattering which later became famously known in the scientific community as 'Raman Effect'.

This special e-screening has been received well garnering 1040 online viewers. The screening has been covered by print, electronic and social media as annexed.

Contd. on Pg.-2/...

: 2 :

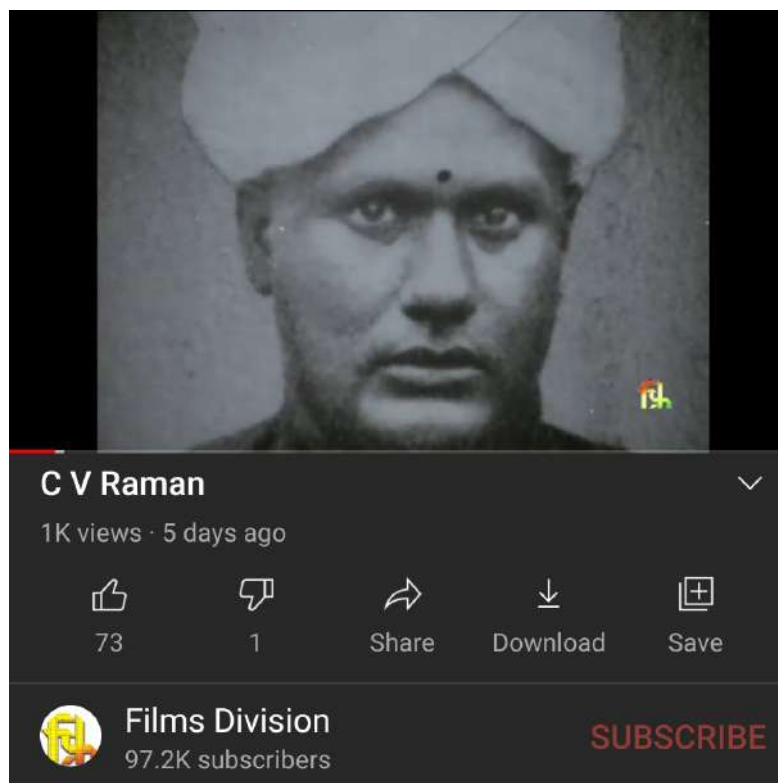
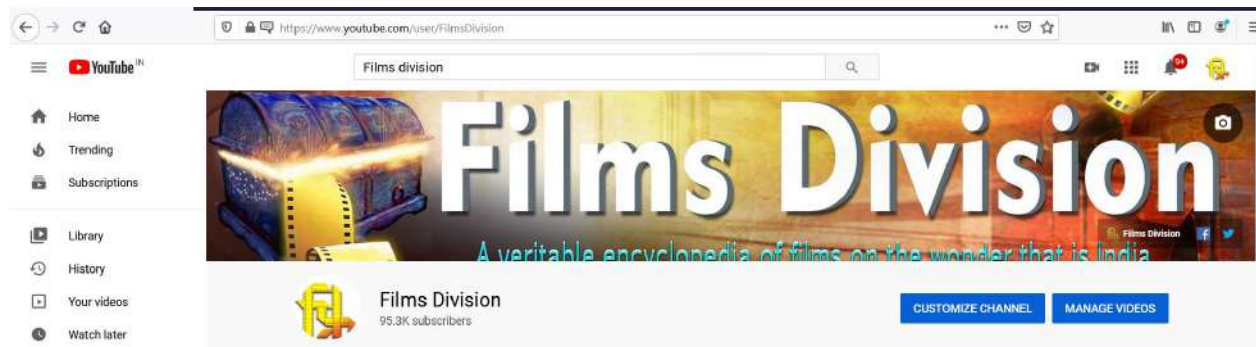
Films Division website



Contd. on Pg.-3/.....

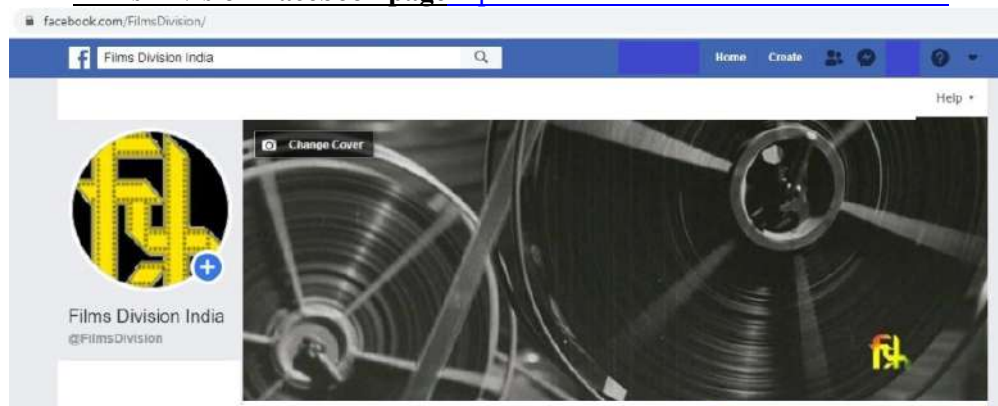
: 3 :

Films Division YouTube Channel



Contd. on Pg.-4/.....

Films Division Facebook page <https://www.facebook.com/FilmsDivision/>



Films Division India 4 d • 🌐

Films Division pays tribute to Prof. C.V. Raman, acclaimed Physicist, Nobel laureate and Bharat Ratna recipient on his 132nd birth anniversary on 7th November, 2020!! Enjoy watching his life and works especially the groundbreaking work he did in the field of light scattering which later became famously known in the scientific community as 'Raman Effect', in C.V.Raman (18 Min./ English) on www.filmsdivision.org/ DocumentaryoftheWeek and <https://www.youtube.com/user/FilmsDivision>.

132nd Birth Anniversary of C.V. Raman
7 November 2020

ONLINE FILM SCREENING
C.V. Raman (18 min. / Col. / Eng. / 1982)
Director - Shankar Gangoo & S.P. Gangoo

To watch, log on to... www.filmsdivision.org (Documentary of the Week section) Or <https://www.youtube.com/user/FilmsDivision> (24 hours streaming)

7 likes • 2 shares

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Films Division pays tribute to Prof. C.V. Raman, acclaimed Physicist, Nobel laureate and Bharat Ratna recipient on his 132nd birth anniversary today by streaming 🎥 C.V.Raman (18 Min./ English) a documentary that throws light on his life and works.

Please log on to www.filmsdivision.org/ Documentary of the Week and <https://www.youtube.com/user/FilmsDivision> to enjoy the film.

Films Division India Ministry of Information & Broadcasting, Government of India Press Information Bureau - PIB, Government of India Press Information Bureau in Maharashtra Children's Film Society, India Doordarshan National (DD1) All India Radio News

132nd Birth Anniversary of C.V. Raman
7 November 2020

ONLINE FILM SCREENING
C.V. Raman (18 min. / Col. / Eng. / 1982)
Director - Shankar Gangoo & S.P. Gangoo

To watch, log on to... www.filmsdivision.org (Documentary of the Week section) Or <https://www.youtube.com/user/FilmsDivision> (24 hours streaming)

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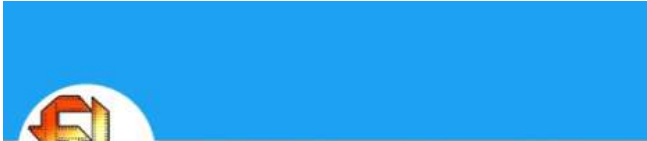
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Films Division established in 1948 under the Ministry of Information & Broadcasting, Government of India.

📍 Mumbai, India filmsdivision.org

📅 Joined November 2016

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Films Division @Films_Division · 4d
Films Division is streaming live C.V.Raman (18 Min./ English), a biopic on the life and works of Nobel laureate Physicist on his 132nd birth anniversary today.

Don't miss watching great moments in the life of Prof. Raman on filmsdivision.org and youtu.be/zlEqLh7P4f4



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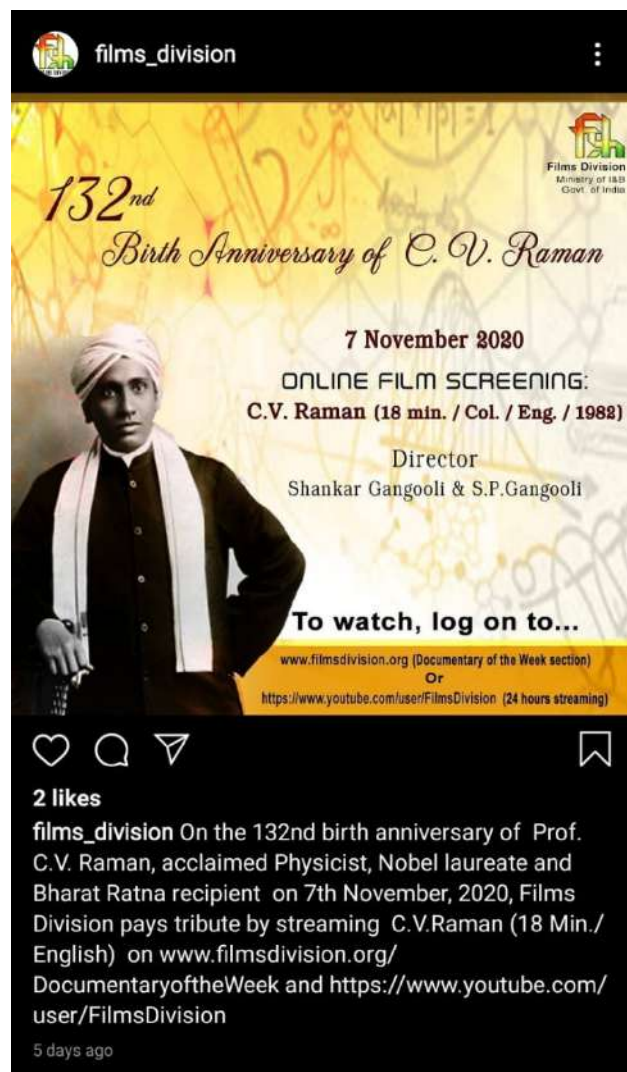
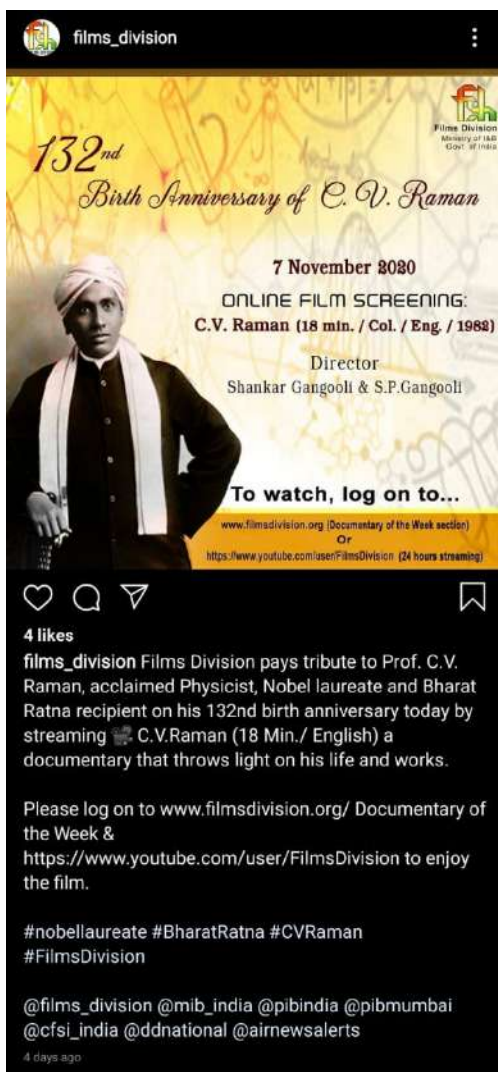
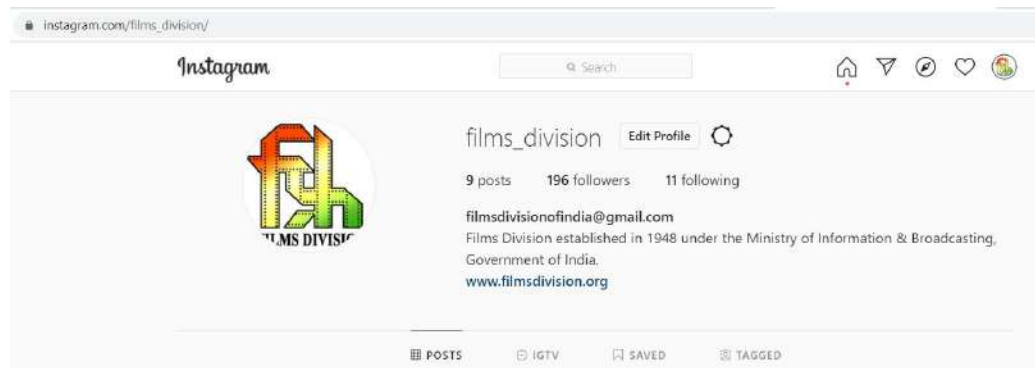
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On the 132nd birth anniversary of Prof. C.V. Raman, acclaimed Physicist, Nobel laureate and Bharat Ratna recipient on 7th November, 2020, Films Division pays tribute by streaming C.V.Raman (18 Min./ English) on filmsdivision.org/ [Documentaryoft...](#) and youtube.com/user/FilmsDivi... @MIB_India



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Ministry of Information & Broadcasting

Films Division Biopic to be streamed as tribute to C.V. Raman

Posted On: 06 NOV 2020 6:35PM by PIB Mumbai

Mumbai, 6 November 2020

The 132nd birth anniversary of Prof. C.V. Raman, acclaimed Physicist, Nobel laureate and Bharat Ratna recipient who was instrumental in India's growth in the field of science and Physics in particular, is being celebrated on 7th November, 2020. Films Division is paying tribute to him by streaming a biopic, *C.V. Raman* (18 Min./ English) on its Website and YouTube channel.



The documentary on Prof Raman throws light into his life and works including the groundbreaking work he did in the field of light scattering which later became famously known in the scientific community as 'Raman Effect'. The biopic will be streamed on <https://filmsdivision.org/> Documentary of the Week and <https://www.youtube.com/user/FilmDivision> for 24 hours on 7th November, 2020.

Films Division/SC/DR

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On the 132nd birth anniversary of acclaimed Physicist, Nobel laureate and Bharat Ratna - Prof. #CVRaman on 7th November, 2020,

@Films_Division is paying tribute to him by streaming a biopic 'C.V. Raman' on its Website and YouTube channel

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DFF India and 9 others



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1. C.V. Raman

- Prof. C.V. Raman's 132nd birth anniversary is celebrated on 7th November, 2020. He was Physicist, Nobel laureate and Bharat Ratna recipient who was instrumental in India's growth within the field of science and Physics.
- Films Division is paying tribute to him by streaming a biopic, C.V. Raman (18 Min./ English) on its Website and YouTube channel.
- The documentary on Prof Raman throws light into his life and works including the groundbreaking work he did within the field of light scattering known as 'Raman Effect'.

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Films Division Biopic to be streamed as tribute to C.V. Raman



(FM) -The 132nd birth anniversary of Prof. C.V. Raman, acclaimed Physicist, Nobel laureate and Bharat Ratna recipient who was instrumental in India's growth in the field of science and Physics in particular, is being celebrated on 7th November, 2020. Films Division is paying tribute to him by streaming a biopic, C.V. Raman (18 Min./ English) on its Website and YouTube channel.

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Biopic to be streamed as tribute to C.V. Raman

By India Education Diary Bureau Admin - November 6, 2020



132nd Birth Anniversary of C. V. Raman

7 November 2020

ONLINE FILM SCREENING:

C.V. Raman (18 min. / Col. / Eng. / 1982)

Director- Shankar Gangooli & S.P.Gangooli

To watch, log on to... www.filmsdivision.org (Documentary of the Week section) Or <https://www.youtube.com/user/FilmsDivision> (24 hours streaming)

Films Division
Ministry of I&IT
Govt. of India

New Delhi: The 132nd birth anniversary of Prof. C.V. Raman, acclaimed Physicist, Nobel laureate and Bharat Ratna recipient who was instrumental in India's growth in the field of science and Physics in particular, is being celebrated on 7th November, 2020. Films Division is paying tribute to him by streaming a biopic, C.V.Raman (18 Min./ English) on its Website and YouTube channel.

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PIB News Update: The 132nd birth anniversary of Prof. C.V. Raman, acclaimed Physicist, Nobel laureate and Bharat Ratna recipient who was instrumental in India's growth in the field of science and Physics in particular, is being celebrated on 7th November, 2020. Films Division is paying tribute to him by streaming a biopic, *C.V. Raman* (18 Min./ English) on its Website and YouTube channel.

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Films Division Biopic to be streamed as tribute to C.V. Raman

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Raman with Spectrograph and Raman Tube



First Raman spectra photographed

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"Raman is like a brilliant cut diamond.
If you rub it on the wrong side,
it will cut your finger."
<<< Rajaji